THE COLOR PRIMER

TEACHERS' EDITION.

BY MILTON BRADLEY

Milton Bradley Co
Springfield, Mass.

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COLOR PRIMER.

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A MANUAL OF COLOR INSTRUCTION FOR PRIMARY AND UNGRADED SCHOOLS, INCLUDING PUPILS' TEXT-BOOK.

BY

Milton Bradley.

MILTON BRADLEY CO., Springfield, Mass.

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NOTE TO TEACHERS.

This little book has been prepared to aid primary teachers in directing, even among their youngest pupils, a logical and truthful study of color. so that, whether much or little is attempted, the time given to the subject shall be profitably used. It has been the aim of the author to crowd as much information as possible into a limited space, but these few pages do not by any means make a complete text book on the subject of color.

The first section furnishes the teacher with a simple and concise explanation of the principles of color analysis and color combinations on which the system of instruction presented in the last two sections is based.

The second section outlines a course of simple lessons, for the convenience of those who may care to use them. But the same object may be accomplished more satisfactorily if the teacher will allow these lessons to suggest others of the same character, because original work often has a great advantage on account of its personality.

The third part, prepared as a pupils' text book and also published separately in that form, is included as a part of this book, for the convenience of the teacher in arranging the lessons. With the text book in use by the pupils their lessons may be so well prepared in advance, that the teacher can profitably give the entire recitation period to experiments and practical illustrations of the subject, or to the desk work which the pupils are doing.

The lessons and experiments outlined in the following pages are not offered as exhaustive in matter or superior in methods of presentation. Any intelligent and interested teacher may be able to devise other exercises equally fit for illustrating the same truths.

The amount of time to be given to the consideration of any subject and the relation of that subject to other studies are matters to be

determined by those who prepare the school programme, but heretofore the teaching of color, if considered at all, has been treated only in connection with drawing exercises. There seems, however, to be no sufficient reason why this relation between these two subjects should be perpetuated to the disadvantage of color teaching in the elementary grades. Color attracts the attention much earlier and more forcibly than mere form without strong colors, and it continues to appeal to us from every direction all through our lives.

The study of color, even when separated from the occupations of drawing, is sure to inspire intense interest if one step follows another in logical succession, so that new and surprising effects are continually developed and clearly explained.

Briefly stated this system is comprised under these five general heads: 1. Spectrum standards; 2. Pigmentary standards based on the spectrum standards; 3. Maxwell rotating disks made in the pigmentary standards and white and black; 4. A color nomenclature based on the accepted standards and their disk combinations; 5. Colored papers made in accordance with these standards and their disk combinations; the whole supplemented by a simple line of water color pigments corresponding to the standards already adopted for the disks.

A deep interest is easily sustained if the pupils are led to see the practical application of the facts which they are learning, and then instead of an isolated study, this color instruction is found to be closely related to every phase of life.

The method and length of the lesson must be determined by each teacher, but short lessons are recommended. Those of not more than fifteen or twenty minutes have been found by experience to be long enough, and such lessons, well illustrated, will create a desire for more.

The consideration of this subject should lead the pupil to see color where he never would have thought of looking for it, to discover harmonies in nature before unrevealed to his closed eyes, and to detect crude and disagreeable contrasts in combinations which had once been viewed with admiration.

PART 1.

AN OUTLINE OF
ELEMENTARY COLOR INSTRUCTION.

ELEMENTARY COLOR INSTRUCTION.

COLOR STUDY MUST BE LOGICAL.

Color is perceived only by the sense of sight, while we discern form by seeing and feeling. Our eyes do all they are designed to do when they enable us to determine form and color. But the perception of form and the perception of color rest upon a very unequal footing in the minds of even well informed persons, and this is on account of the popular knowledge regarding form and the very meager information about color.

Geometry has been for many years a common study, based on universally accepted standards of measurement, which have provided definite terms in which certain mathematical facts regarding form can be expressed. The measures of length, such as the foot and meter, and the divided circle by which angles are designated, compared and recorded, have placed definitions of form within the range of the exact sciences, and made them familiar to the general reader.

But no such advantages have ever obtained in the department of color. Here there has been no system of measuring or even naming colors in any definite terms, because the popular words relating to the subject are few and are used so loosely that they have slight practical value. The reason of this is that little was known about the physical qualities of color until within a comparatively short time, and also because the artists and colorists have been so wedded to false theories that they have failed to heed the important scientific facts regarding color, which have come to be unanimously accepted by physical students during the last half century.

This indifference and consequent popular ignorance have delayed the general adoption of well defined terms for carrying on intelligent conversation regarding colors, as may be plainly seen by reference to the definitions of color terms in our best dictionaries and cyclopedias. Tint, shade, hue and tone are four words commonly employed in speaking or writing about color, but common usage has not yet justified the editors of our leading dictionaries in adopting such accurate definitions as are warranted by the facts generally accepted and adopted in the modern scientific treatises on color.

The study of form which Frœbel first introduced into the lowest grades of instruction, has been the active force to develop a definite use of simple geometric terms by our young children, such as would have been considered unnaturally mature a generation ago. But although color was at the same time prominently introduced in Frœbel's kindergartens, no corresponding advance educationally has been made in its consideration because as we have said, there have been no popularly accepted terms for the definite expression of common color facts.

It is not necessary that the youngest pupils learn much, if anything, of the *science* of color, neither is it expected that they will study geometry, but it is desirable that every teacher in the lower grades of our schools shall possess so much information regarding both color and form that she will not unconsciously cultivate, in the minds of the children under her care, impressions regarding these subjects which they may later discover to be untruthful.

The study of color, either by the adult or the youngest child should be conducted in a logical way, and must be founded on facts to give best results. The truth has been demonstrated that color, in whatever form or material it may be seen, is produced by physical phenomena, which are well understood by the students of to-day, and that it is perceived by means of physical and psychological impressions regarding which there is no longer great mystery, but for which reasonable theories have been formulated and generally accepted.

It is the aim of this little book to present briefly and as clearly as possible an outline of the latest methods of color study based on demonstrable facts concerning color, some-

what as the modern system of form study is necessarily founded on the mathematical facts of form as embodied in geometry, and the modern system of music on the number of vibrations of material substances.

THE LAWS OF COLOR MUST NOT BE VIOLATED.

A drawing which violates truths regarding measurements and perspective is relatively valueless, no matter what may be the quality of line and the handling of light and shade. So no painting can successfully withstand intelligent criticism if it violates the laws of color, which although possibly more subtile than those of form, still as surely exist and are coming to be as clearly understood.

A prominent educator says concerning the system here very briefly set forth, "The principles of chromatic harmony are perhaps not simple, but a child before whom right standards of color combinations are constantly presented will acquire a correct æsthetic judgment that may become intuitive. The effect of such training on the higher development of our people and on their true appreciation of art must be of the greatest value."

SOLAR SPECTRUM-NATURE'S CHART OF COLOR.

The solar spectrum has been called nature's chart of color, and while this may not be even approximately true, yet in it we must recognize the only source of permanent standards on which a logical system of color study and color nomenclature can be formulated.

The scientist with his expensive and elaborate apparatus can produce in a very dark room a wonderfully brilliant and beautiful solar spectrum, so intense and immovable that it can be carefully studied and analyzed for hours and days, and it was these conditions which enabled a company of interested educators to evolve the scheme of color study here advocated. Equally favorable conditions and apparatus are not necessary for elementary color instruction, although the writer has often wished that every teacher and every child could for once see a solar spectrum as perfect as can be produced with the apparatus of the modern physical laboratory.

This being ordinarily impracticable each teacher must use the best available facilities, and may always be sure that a spectrum, how-

ever imperfect, will be interesting to the children. For these experiments a very good prism can be bought for fifteen to thirty cents.

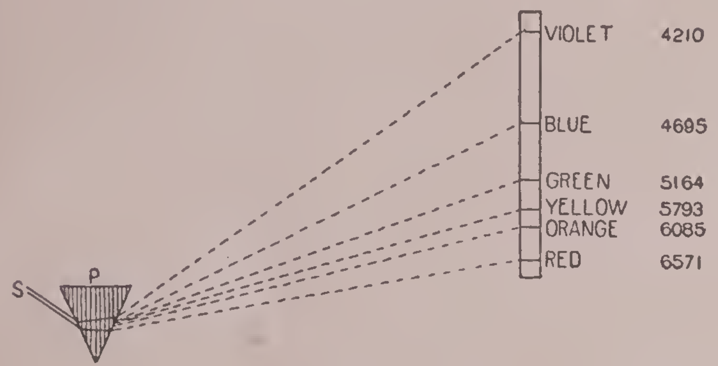


Fig. 1.

Fig. 1 shows the relative position of the several features in this experiment as it can be presented in a schoolroom having a southern exposure. S is the sunbeam, P the prism, and the dotted lines represent the variously colored rays of light into which the white sunbeam is separated by passing through the prism, thus forming the spectrum on the screen or ceiling, with violet at the top and red at the bottom. The prism may be held in the direct rays of the sun and the spectrum thrown on the ceiling wherever it may strike, or if the windows can be darkened by heavy curtains or thick wrapping paper, a small hole in one of the curtains may be made to admit a beam of light without lighting the room very much. In any event the effect will be improved if the spectrum is thrown to the darkest corner of the room.

The explanation of the phenomenon of the spectrum is that the beam of white sunlight is composed of a great number of different kinds of rays of various colors, which in passing through the prism are refracted or bent from their direct course, some more than others, the red least of all and the violet most, and thus the white sunlight is made to present a beautiful band of color called the solar spectrum. It is supposed that light is projected through space by waves or undulations in an extremely rare medium called ether which occupies all space and transparent bodies. These waves are thought to be somewhat similar to sound waves in the air or the ripples on the smooth surface of a pond when a pebble is thrown into it. According to this theory a ray of light in passing through a prism is refracted from a straight line in proportion to the number of waves or undulations per second, and in in-

verse proportion to the length of the waves. The red waves are the longest and are refracted the least, while the violet are the shortest and are refracted the most.

The colors in a solar prismatic spectrum are always the same under like conditions and the order of their arrangement is never changed. By this quality of wave-length which is constant, any spectrum color can be definitely located in the spectrum, and hence can always be referred to by its recorded wave length, and therefore can be used as a permanent, unvarying standard of color.

NUMBER OF STANDARDS.

In selecting definite spectrum colors to serve as standards, the number required is the first consideration.

A careful study of the theories and experiments of the past seems to confine this number within the range from three to seven.

Sir Isaac Newton thought there should be seven, and Sir David Brewster, who lived and experimented one hundred and fifty years later than Newton, believed that he had discovered a new theory which limited the standard or primary colors to three, red, yellow and blue, a theory which has commonly been accepted by artists, although long ago discarded by scientists.

Later investigation has determined that in a strictly scientific consideration of *pure sunlight* there are three colors, red, green and blue-violet, from which, in various combinations, all other pure sunlight color effects can be produced, and which in that sense may be considered as primary colors, but they are of no practical value in the æsthetic consideration of material colors. Experiments have proven that from red, yellow and blue, it is impossible to produce all other color effects, either in sunlight colors or in pigments, and hence neither of these triads of colors can have any claim to favorable recognition as a complete set of standards in the study of material color effects.

The seven standard colors of Newton comprised red, orange, yellow, green, blue, indigo and violet, but recent investigation has demonstrated that there is no advantage in the recognition of indigo, which is a violet blue, as a standard and that a list comprising Newton's six other colors is sufficient, and not

larger than is necessary for best results in establishing a practical nomenclature of color and in the study of the æsthetic truths regarding colors.

THE BRADLEY STANDARDS.

For such standards the most intense expression of each color is chosen, i. e., the reddest red, greenest green, etc., and these have been accurately designated by their wave lengths, so that they can be referred to at any time for comparison or discussion. Thus these standards have been chosen first by the æsthetic sense and afterwards established and defined by scientific methods.

The wave lengths of these six standards are represented by the following numbers in tenmillionths of a millimeter: Red, 6571; Orange, 6085; Yellow, 5793; Green, 5164; Blue, 4695; Violet, 4210. These colors having been selected in accordance with the trained perceptions of a considerable number of competent persons comprising artists, teachers, and others, as the most desirable standards, the attempt has been made to secure the best possible imitations of each in material colors, such as pigments, papers, etc., to serve as material or pigmentary standards of color. While the spectrum colors indicated by the above numbers are unchangeable and serve as permanent standards, their material representations must necessarily be imperfect and subject to improvement in the future, as chemical processes in the manufacture of pigments may afford purer imitations of the spectrum standards. But the improved pigments will still produce the same colors as before, only purer and probably more intense, and hence will represent the same spectrum standards from age to age.

The best material color is but a weak approximation to the pure spectrum color, but the one aim must be to secure the same kind of color, as for example an orange neither more red nor more yellow than the location in the spectrum chosen for the standard orange.

For educational purposes special coated colored papers are not only the cheapest material, but fortunately afford the purest colors to be found in convenient form.

From the pure spectrum colors, i. e., the sunlight colors, it is possible by reflection to combine two adjacent standards in various

pairs to imitate other spectrum colors between the standards.

For example, if two small mirrors are held in a spectrum, one at the "red" and the other at the "orange" so that the two colors are reflected upon the same spot on a white surface the result is a color between red and orange. So also if we mix red and orange pigments together we may produce various colors between the two which will be orange-red or red-orange as the relative quantity used of each may be changed; but there is no way by which the quantity of color effect produced by the use of each of the standards can be measured and thereby recorded.

THE MAXWELL DISKS.

We have however in the "Maxwell rotating disks" a means for imitating, measuring and recording material color effects, which is at once convenient and accurate, and the results correspond in principle with those secured by combining the spectrum colors by means of the mirrors, as also the effects in nature caused by reflected colored lights.

Every boy knows that if he rapidly whirls a lighted stick, the coal of fire at the end produces a circle of light, which phenomenon is caused by the quality of the eye called retention of vision, by which the impression made on the retina remains during an entire rotation of the point of light. By the same quality of vision, when one color is presented to the eye and instantly replaced by another the effect is a combination of the two colors to form a new color.

Therefore if for example one quarter of the surface of a disk of cardboard is covered with red paper, and three quarters with orange paper, and the disk rapidly rotated on a spindle, the result is a new color which is a mixture of these two, or a red-orange. Another most valuable feature of this phenomenon is that the resulting color is directly in proportion to the angular measurement of the two sectors of color formed by the overlapping disks, so that if the circumference is divided into 100 equal parts the resulting color will be definitely named by the formula "Red 25; Orange 75," or in general terms as a reddish orange or red-orange.

More than two hundred years ago Sir Isaac Newton made use of this fact by painting

various colors on the flat surface of a spinning top, and he succeeded in producing a neutral gray effect by using seven colors which he then thought necessary to secure the result. Less than fifty years ago an English scientist, J. Clerk Maxwell, while experimenting with similar painted surfaces of cardboad, conceived the idea of combining two cardboard disks of different colors by cutting a slit in each from circumference to center, so that by joining them he was able to show varying proportions of each and thus, by rotation, to produce various colors.

COLOR WHEEL AND COLOR TOP.

This is clearly seen in the familiar "color top" already in common use in primary schools, and is also shown by the larger disks of the "color wheel." The color wheel is for demonstration before a class or school and to be operated and explained by the teacher. The color tops are for individual use by teacher or pupils. Both are not necessary in the same school but are desirable. With the wheel alone the teacher must do the work, demonstrating the facts as she explains them. If the tops only are provided the teacher and each child in the school or class should have one so that the children may imitate the experiments shown and explained by the teacher. If both are available general instruction may be given by demonstrations with the color wheel, each pupil repeating the experiments with the top. In the top the disks are made from colored papers in two sizes, about 3-4 of an inch and 1 1-2 inches in diameter. The disks of the primary school color wheels are in three sizes, from 3 inches to 7 1-2 inches and are of cardboard.

In commencing work with the rotating disks and colored papers made in accordance with a system based on their use, one must once for all discard the old myth that the three primary colors, red, yellow, and blue, have any reason for their existence as *standards* on which alone to base color education or color practice.

A set of colors to be used as standards in any system of color investigation or instruction must be such that practically all other colors of equal purity can be made from them by combination. The smaller the number that will meet this test successfully, the better, because of the greater simplicity of nomenclature that will be possible. As has been

stated, three are insufficient, and extended experiments have shown that six are enough, with the added advantage that the already recognized colors most familiar as types, if secured in uniform purity are the most useful, namely, red, orange, yellow, green, blue and violet, with the addition of black and white, thus confirming the value of this psychological selection made by the æsthetic sense.

COLORED PAPERS.

Having considered thus far the standards chosen in the spectrum and located by their wave lengths, and coated papers made in the closest possible imitation of these six spectrum colors and also of white and black, and having accepted the rotating disks as a means for combining these eight standards, in various selections and proportions, the next step in the logical sequence has been the preparation of a full line of educational colored papers based very largely on these standards and their disk combinations on the rotating spindle. In this selection of typical papers two hues between each adjacent pair of spectrum standards and also between the red and violet have been chosen, thus joining the two ends of the spectrum and forming a "spectrum circuit." These twelve colors, for convenience, are termed intermediate spectrum hues, simply as a technical distinction from the six standard colors and white and black. Two of the intermediate hues are chosen, instead of a larger or smaller number, because by this selection a more natural nomenclature is secured. For example, between the yellow and green there is a green-yellow nearer the yellow, and a yellow-green nearer the green. A larger number of these intermediate colors would be confusing for primary work and if a more accurate nomenclature is required for any color the disks of the color wheel or top will furnish it exactly, as no other means can.

TINTS AND SHADES.

If Maxwell disks, made from all the standards and intermediate spectrum hues, are each individually combined with a white disk on the color wheel, a series of tints of each of these colors is the result. Tints may also be made by mixing white pigment with the colored pigment, or by diluting water colors with water. As these tints may be lighter or darker their tones will differ, and for our educational

papers two tones of each of the tints have been chosen, of which the deeper tint nearest the standard is for convenience called No. 1 and the other, which is lighter, No. 2.

If a color disk is combined with a black disk by rotation or if a shadow is thrown upon the color, or a dark neutral pigment mixed with the color the result is a shade of the normal color, and thus we may select two shades for each color which with the normal color and its two tints will form a scale of color in the five tones, a number sufficiently large to serve as types in primary color instruction. For example the standard red with red tints No. 1 and No. 2 and shades No. 1 and No. 2 will furnish the red scale in five tones, viz: standard, two tints and two shades. If we combine color disks and behind them on the spindle place a graduated disk showing the circumference divided into 100 parts, we may definitely note and record the quantity of each color employed in any combination and thus we can accurately name and make record of any color.

As thus far described we have provided for a series of typical colors consisting of eighteen scales of five tones each, making ninety examples of pure spectrum colors and their tints and shades.

BROKEN COLORS.

If we combine a white and a black disk in various proportions we secure by rotation a series of grays, which are typical colors because they are absolutely devoid of spectrum color, i. e., are absolutely neutral grays. These grays are very perfect imitations of a white surface in shade or shadow, which cannot be *guaranteed* in any pigment gray.

As the orange disk for example, when combined with a white disk, gives a tint of orange and with black a shade of orange, if we combine it with both a white and a black disk the result will be a gray orange or a broken orange. This is an example of an entirely distinct class of colors which may be arranged in a number of scales, to form a series of typical "broken colors," similar in arrangement to the chart of spectrum colors and representing a very large and wonderfully beautiful class of colors in nature and art. These broken colors will be further noticed and explained in the second part of this book.

MATERIAL OR PIGMENTARY COLORS.

While the attempt has been made to secure the best possible imitation of the spectrum standards in material colors, to serve as pigmentary standards, the result is very far short of the high aim, and yet it is fortunate for the cause of primary color education that colored papers are at once the best and the cheapest material to be found.

All material colors are more or less fugitive and some much less permanent than others, while all fall very far short of the spectrum standards, but improvements in the manufacture of pigments are constantly being made in both their permanence and purity of color. Therefore pigmentary material standards will not remain absolutely the same from generation to generation, but they will still be impure material standards when referred to and compared with the pure, unchangeable standards of the solar spectrum.

CHEVREUL'S "SIMULTANEOUS CONTRASTS."

Thus far our consideration of color has been practical and analytical, somewhat as form is treated in geometry and trigonometry. There are, however, subtle effects in certain forms which render them pleasing to the eye but which are not directly referable to any of the simple geometrical type forms. So also in color, perhaps to a greater extent, we find peculiar æsthetic effects which could not have been predicted from the ordinary combinations and analyses of type colors. Prominent among these peculiar effects and perhaps controlling them altogether is the phenomenon commonly termed the after image or accidental color.

The reasons for these effects or illusions as far as they are understood can be learned from any modern treatise on physics, but the phenomena have furnished the basis for a book of five hundred pages written by M. Chevreul, a French chemist in charge of the dyeing department of the famous Gobelin Tapestry Works. This author first discusses these effects under the single term "Simultaneous Contrasts of Color," which he afterwards divides into "Simultaneous," "Successive," and "Mixed" contrasts. This division does not seem to simplify the subject and possibly serves to obscure the truths, which are included in the first term, simultaneous contrasts.

It may also be noted here that the deductions of Chevreul would have been somewhat different and much more valuable if he had not believed in the false theory of the three primary colors, red, yellow and blue, which seems to have warped his judgment if not his vision, as it has that of many artists and artisans before and since his day.

This entire phenomenon in all its phases is dependent on the so-called after-image, and in it may perhaps be found the cause for a majority of the best harmonies and some of the most disagreeable discords in color. A single simple experiment gives a hint of the nature of these effects. If one's eyes are fixed intently for a half minute on a spot of red, for example, and then turned to a white surface, a spot like the other in form but of a faint color between blue and green, a blue-green, will be seen. This appearance is also called the accidental color and it is practically the complementary color to the red but very much less pure and full, in fact a tint of the true complementary of red.

The details of these effects are elaborated in the form of experiments in our second part, and it is by such means only that they can be discussed, but it may be said here that while all that is due to this phenomenon may not as yet be fully understood, a very large part of those subtle and sometimes fleeting color effects, which are experienced in nature and art, are due more or less to this series of phenomena.

While it is true that art cannot be originated by means of mathematical rules, yet artistic effects may often be analyzed and recorded in scientific terms by which they can be repeated or imitated more or less perfectly.

The sole æsthetic aim of color study is to cultivate color perceptions so that we can appreciate good color combinations, perhaps be able to imitate them and possibly to improve on them. The experiments suggested in this direction if properly presented may go very far in making clear many things now hardly comprehended by some who have practiced long in art lines.

PART II.

SOME EXPERIMENTS

IN COLOR FOR ELEMENTARY INSTRUCTION.

EXPERIMENTS IN COLOR.

THE PRISM.

While it is true that the solar spectrum does not contain examples of all the colors in the world, it falls but little short of doing so, and its presentation is a suitable and attractive experiment with which to introduce the subject of color to child or adult.

Although a prism is such a very simple affair the teacher will do well to try it in the schoolroom without the children the first time, so that the best position for its use may be discovered. If it is not practicable to throw the spectrum on a white wall a sheet of white cardboard should be hung so as to receive it. Having previously determined the best conditions at a given time of the day, the management of the prism will be an easy matter when the lesson hour arrives.

It is not possible to produce in a well lighted room a spectrum sufficiently brilliant to clearly define the six standard colors, Red, Orange, Yellow, Green, Blue and Violet, but even under these conditions a beautiful spot of various colors may be seen and some of the colors named by the children. With closed blinds or dark curtains drawn, very good results may be secured and the children can see that red is at the bottom of the spot of color, and that the other colors follow in order, with a wide band of rather indefinite violet at the top. They can be told that the sunlight contains practically all the colors that are seen in the world, and that the reason we see the red of the rose is because the flower eats up all the colors except the red, which it gives back to us for our pleasure. The statement that all surfaces except white absorb some of the colored rays and reflect others may be reserved for a much later lesson in natural science.

In examining the spectrum the colors may be considered in their order, commencing with the red and proceeding to the violet; or as some have practiced, first call the attention of the pupils to the outside colors of the spectrum, the red and violet; next take the two colors which follow these, namely, the orange and blue, and lastly study the yellow and the green, the central colors of the spectrum band. The orange very likely may be found to be the most difficult one to distinguish and therefore will require greater care.

The preference of the children for the several colors may be asked for, and in various ways which will suggest themselves the pupils may be interested in the subject of color.

COLORED PAPERS.

After the prism has been considered, colored papers are the most available means for imparting earliest impressions regarding color in a systematic way, but the spectrum should be repeatedly shown until it is familiar to the children, and a paper spectrum may be kept constantly in view.

Give to each child a set of paper tablets in which the six colors of the spectrum are found. Very convenient material is found in a series of papers 1 inch wide by 2 inches long, put up in four envelopes containing various assortments, under the general title of "Educational Colored Paper Tablets for the Bay State Course in Color Instruction."

No. 1 envelope contains the six spectrum colors, with white, black and neutral grays.

No. 2, the six standards, with tint No. 1 and shade No. 1 of each.

No. 3, the eighteen spectrum colors from violet-red through the spectrum circuit to red-violet, with white, black, two tones each of neutral gray, cool gray, warm gray, and green gray.

No. 4, the eighteen spectrum colors as above, with tint No. 1 and shade No 1 of each.

Beginning with Envelope No. 1 ask each pupil to select the papers like the outside colors of the spectrum; match the colors next to these in the same way, and lastly the central ones, yellow and green, or the colors may be selected and arranged in the spectrum order from red to violet. Tell them that all these colors and many more are in the sunlight, and ask if the spectrum reminds them of anything

they have seen before, as the rainbow, or the sun shining through a glass of water.

Call attention to the fact that these six colors are the ones most clearly seen in the spectrum, and tell the pupil that they are called the *spectrum standards*. These colors must be observed until they become fixed standards, the child's own property just as much as the mental image of the cube or the sphere. Each standard must be made the subject of particular study, and fixed in the mind by comparison with the spectrum. If the child thinks when he sees red, "This is like my spectrum red," and forms a correct conclusion, he is ready for orange and so on with each of the colors.

When these six colors have become so familiar to the children that they select them readily by name and lay them in the spectrum order, they may be asked to bring from home for comparison, samples of any color or colors which they may find, such as bits of cloth or paper, flowers, leaves, etc. As it will probably be impossible for them to find as pure colors as the papers this suggestion should not be made before the pure type colors of the spectrum are well fixed in the perception of the children, for as soon as these miscellaneous samples are considered they must be told that these colors, red for example, are not the pure standard red, but that there are many kinds of red besides the standard and that in time they will learn what to call them.

No teacher can assume to dictate to another exactly the order in which color instruction shall be imparted in the earlist stages, and these brief suggestions can indicate only a most elastic program, always subject to modification in accordance with experience and conditions.

Allow the children to group the colors that are similar and try to develop in their minds the idea of resemblance and difference of colors, and bring out the fact that while there are many similar colors there is only one standard of a red, an orange, etc., and that to the standard colors we give the names red, orange, yellow, green, blue and violet, by which standards all colors are tested and classified, and hence the importance of training the eye to recognize the spectrum standards readily.

There is as yet great difference of opinion

among competent teachers as to the methods of presenting this subject in the very earliest years of the child's experience. It is quite difficult to tell a child truthfully why a sample of red cloth brought from home is different from his red paper tablet. In fact this is often a problem which can be solved correctly only by actual experiment with standard color disks. Hence it is a pertinent question how early to bring to the child's mind the comparison of miscellaneous material with the standards. The writer does not here assume to recommend any detailed course except so far as such sequence is indicated in the selections of colors in the four collections of paper tablets already mentioned, and even this sequence in detail cannot be urged arbitrarily as better than all others.

To illustrate: Without doubt the six standards should be first learned and also white and black immediately following, but it is an open question whether the consideration of tones or of hues may most profitably follow that of the standards. In the "Bay state course" the former has been adopted and is followed here.

TONES.

An early lesson on light and shade may be given with a book bound in some distinct full color, as red. Hold it with the back towards the pupils and vertical so that one cover will be illuminated by the fullest possible light from the windows, while the other cover receives the ordinary light of the room. Call attention to the strongly lighted cover as lighter than the other or a tint of the other one. Then turn the book so that the cover which

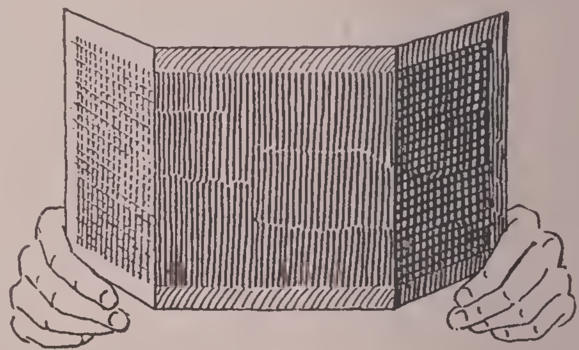


Fig. 2.

before was in the bright light is in the ordinary light and the other cover in shadow. These effects can also be shown by a very simple model made with a piece of red paper attached to a stiff paper back by merely a few touches of

gum at the edges, and then the whole folded as shown in Fig. 2. The central face will give the normal color, while one side will be a tint and the other a shade.

After having shown the true effect of light and shade with the book cover or folded card a color disk may be combined with a white disk in various proportions to form tints, and with a black disk to produce shades.

At this stage the pupils will be ready for the paper tablets in envelope No. 2 consisting of the six standards with a tint and a shade of each.

In the consideration of tints and shades of colors or the tones of colors we must keep in mind the true white sunlight tints and shades and also the imperfect imitations of them which are possible in pigments.

Pure white light, as good daylight with a slightly hazy sky in a fairly well lighted room, gives a normal or standard color. A stronger light produces a tint and a reduction or obstruction of light a shade. These effects give true tints and shades and are those obtained in the experiments with the folded card as above described.

If the sunlight is modified by any means, as in a red sunset effect, the tints are not true as compared with those in white sunlight. In making imitations of true tints and shades there are two principal methods or means, first the rotating disks, and second white and black pigments.

In making tints by the use of the white disk with a color disk there is quite a definite imperfection which seems like the introduction of a slightly violet effect. This is seen more prominently in the red and the blue tints perhaps than in any of the other colors.

Pigmentary tints made by the mixture of white pigment with a standard color are more nearly like sunlight tints than the disk combinations. But on the other hand the shades made by the black disk in combination with a color disk are very much more correct than those secured by the admixture of black pigment with the pure pigment color. In fact the black disk effect is practically a true imitation of the color in shade or shadow.

Hence while not entirely perfect the tones in tints and shades secured with the rotating disks are fully as true as can be made in any

other way with the added advantage that the grade of the tone whether tint or shade can be definitely measured and recorded, which is not possible by any other means.

INTERMEDIATE SPECTRUM HUES.

With the introduction of tablets No. 3 comes the first presentation of the spectrum colors between the standards, as for example the orange-red and the red-orange, between the red and the orange, or the yellow-orange and the orange-yellow betweeu the orange and the yellow. In the spectrum represented by the papers there are ten of these intermediate colors. There will also be found two other colors, violet-red and red-violet, which are not in the spectrum but are found in nature and the arts aud generally known as purples. If all these papers are pasted upon a strip of paper in their proper order and the two ends joined, this exhibition of color may be called a spectrum circuit and becomes a very important feature in the analytical study of color.

The combination of two adjacent spectrum colors to make intermediate hues is very beautifully and rapidly shown with the disks on a color wheel or color top. Right here it must be thoroughly impressed on every mind that in these combinations of standards either by means of the disks or in pigments, only those two colors must be used which are adjacent in the spectrum circuit. The reason for this restriction is explained further on.

VARIOUS GRAYS.

Neutral No. 1	Cool No. 1	Warm No. 1	Green No. 1
Neutral No. 2	Cool No. 2	Warm No. 2	Green No. 2

Fig. 3.

In this same envelope, No. 3, are found tablets in various grays,–neutral gray, cool gray, warm gray, and green gray. The grays may seem on first thought less attractive than the brighter colors, but there is a subtle interest in the study of them which appeals to the child and adult alike when the subject is properly considered. The grays can be made in great variety by the use of the rotating disks and the pupil will learn how gray or broken colors merge into colored grays of which the warm and cool grays are principal types. After the

gray tablets have been studied by laying them in various relations to each other, they also may be mounted on a bit of heavy paper in the order which best brings out their differences, and thus may form a valuable chart for future reference by the pupil as shown in Fig. 3.

SPECTRUM CIRCUIT.

As already explained in part I, we find in the solar spectrum types of all pure colors, except the purples between red and violet of which the red-violet and violet-red papers furnish examples.

If these eighteen papers found in envelope No. 3 are mounted side by side on a strip of paper and the ends joined to form an endless belt, with the colors on the outside, the arrangement of colors may be called a spectrum circuit, which is a convenient name to give this endless sequence of colors.

The tablets in envelope No. 4 furnish material for this entire spectrum circuit with a tint and a shade of each color. See Fig. 4.

After having carried pupils up to this stage with the three preceding sets of tablets, each teacher will no doubt have her own opinion as to the best use to make of those in envelope No. 4. They serve as a review of all that has gone before, involving standards, hues of the standards, and a tint and shade of each of the eighteen colors in the spectrum circuit. The mounting of these to form a chart, showing in the central column the spectrum circuit in eighteen colors and on either side a tint and a shade of each, will furnish a final test of color preception of no mean quality, and if retained by the pupil such a chart may long be a source of much pleasure and value to others who may have had no logical instruction in color.

V.R.T.1.	V.R.	V.R.S.1.
R.T.1.	R	R.S.1
O.R.T.1	O.R.	O.R.S.1
R.O.T.1.	R.O.	R.O.S.1
O.T.1	O.	O.S.1
Y.O.T.1	Y.O.	Y.O.S.1
O.Y.T.1	O.Y.	O.Y.S.1
Y.T.1	Y.	Y.S.1
G.Y.T.1	G.Y.	G.Y.S.1
Y.G.T.1	Y.G.	Y.G.S.1
G.T.1	G	G.S.1
B.G.T.1	B.G.	B.G.S.1
G.B.T.1	G.B.	G.B.S.1
B.T.1	B.	B.S.1
V.B.T.1	V.B	V.B.S.1
B.V.T.1	B.V.	B.V.S.1
V.T.1	V.	V.S.1
R.V.T.1	R.V.	R.V.S.1

Fig. 4.

The foregoing exercises should be varied by the frequent use of color disks, first by the teacher on the color wheel and then repeated by the pupils with their tops, or if the wheel is not provided, the use of the tops alone will serve the purpose, the teacher

having one in her hand and showing the manipulation and explaining the reason for the selections of the disks. In the colored papers the variety of hues and tones is limited, but with the disks unlimited, and thus, passing beyond the restricted experiments with the papers, the use of the rotating disks gives us the means for elaborating beautiful theories and establishing valuable facts.

Up to this point nothing has been said of other colors than full pure colors and their tints and shades, except in the four kinds of grays. Of these the neutral gray is a pure gray if we may so call it, i. e., a standard gray; the other three grays are colored grays. Of these the warm grays have, with the neutral, some color from the red and orange end of the spectrum, cool grays something approaching the blue, and green grays, as their name indicates, green.

BROKEN COLORS.

The most interesting class of colors, comprising a very large majority of the material colors, has not been mentioned, the so called "broken colors" which are gray colors. These are shown and taught far better by the use of rotating disks than in any other way; in fact the investigation which led to the system of color instruction here advocated first demonstrated the nature of these colors which include the tertiaries of the Brewster theory.

If we put a piece of pure red material in the sunlight, much of the color disappears and we have a tint of the color which can be imitated by mixing white with the pigment. If we prepare a shade of the same red by introducing black into the pigment and then place it in a strong light we have a tint of a shade of the red. This is a broken color and is very simply imitated by the use of color disks. For example: If we rotate an orange disk and a white disk combined we have a tint of orange, if an orange disk and a black disk, we have a shade of orange. If we now combine with the orange disk both a white and a black disk we shall have a tint of a shade or a shade of a tint, which is a gray color or a broken color. This is seen to be so by analyzing the disk combinations, for a white and a black disk combined invariably give neutral grays, and if to these we add a color disk we have a gray color, or a series of gray colors as the proportions are varied.

This is still further complicated but is not rendered any more difficult to understand when we experiment with a red-orange instead of a pure orange, because we could make a disk from a piece of red-orange paper and add white and black disks to it. But this is unnecessary because the red and orange disks produce the same results and also afford us a correct analysis of the resulting color in its simplest terms, i. e., in terms of spectrum standards. Experiment has demonstrated that every color in nature or the arts can be imitated and analyzed, and named in not more than four terms, namely two standards, and white and black. A color must be either a full spectrum-circuit color or a tint or a shade of such a color or it must be a broken tone of a spectrum-circuit color. Therefore every color can be imitated with not more than four disks, and named and recorded in terms of the accepted standards.

So that whenever the whole world shall agree on six spectrum colors for standards, there will be established a universal language of color as there now is of music, based on scientific facts and phenomena, a result never approximated before this system was elaborated and still impossible by any other known methods.

The standards named in the system here advocated have been adopted after many years of experiment and practical use, and they have been located by their wave length in the several parts of the spectrum where they always occur, and will always be the same.

In the old but erroneous Brewster theory of three primaries, red, yellow and blue, three secondaries, orange, green and purple, and three tertiaries, russet, citrine and olive, the tertiaries were supposed to possess some subtile and peculiar value, resulting from the combination of two of the secondaries. But the system of color analysis here taught for the first time demonstrated that these are all broken spectrum colors, and not peculiar in any way.

For example a "russet" is a broken orange-red or red-orange. The "citrines" cover the colors between orange and yellow, although the term is so indefinite in the popular mind that hardly two color critics will agree as to what range of colors it includes, while the "olives" are a line of broken green-blues or blue-greens.

ANALYSIS OF COLORS.

When the children have become familiar with the principles and facts regarding color thus far outlined, they will be intensely interested in analyzing and naming the colors of many things which may be brought into the school room, and for this work before a class the color wheel is very useful as all in the class or the room may engage in the same work at one time.

For such exercises the teacher may secure pieces of colored cloth or odd colored papers and many other kinds of manufactured or natural materials. Cloth or paper can best be examined by cutting a disk of any convenient size for use on the wheel, and placing it on the rotating spindle in front of the Maxwell disks selected for the analysis which of course must be larger than the sample. If the sample piece of material to be examined is large enough one of the smallest disks of the color wheel may be used as a pattern for cutting the material, and thus the hole may be accurately located at the center of the disk, which is quite necessary for good results.

Very thin material may be fastened to a thick paper disk previously cut, and only a little pasting is necessary at the center and possibly three or four points at the circumference.

A general interest may be secured by showing to the class the sample to be analyzed and asking them to name its color by telling which disks must be used to produce it by rotation. Such an exercise is sure to be interesting and instructive if properly conducted, no matter what the color or material may be.

If other substances than cloth, paper, etc., are to be experimented with, the object may be held in good light as near as possible to the rotating disks.

With the color top instead of the color wheel flat surfaces like paper, cloth, book covers, etc., can be best examined by spinning the top on the material and looking down on both while the top is in motion.

Where pupils have the use of color tops a pleasing variety in their work may be introduced by allowing them to analyze the colors of common flowers and leaves. In this way two purposes may be served, for the color perceptions will be sure to be quickened and also

the love of flowers cultivated by such employment. At first a single flower or green leaf may be examined each day, the colors being imitated with the disks and the tops shown to the teacher for comparison with the flowers. The older children may make tests and record the results in a memorandum book.

The very unsatisfactory condition of color nomenclature in the past may be emphasized to the class by ascertaining the fashionable names of some new colors of dress goods in the market and comparing them with the true names of the same material as indicated by the disks.

In color analysls and color nomenclature by meàns of the rotating disks the fact must be constantly held in mind that not more than two spectrum standards are necessary in the matching of any color, and never more than four disks. If the color is not a modification of one of the spectrum standards it must be some form of an intermediate spectrum hue. It may, for example, be a tint of a yellow-green, in which case a yellow disk, a green disk and a white disk will be necessary, and if a shade of the same color, the green and yellow disks with a black disk will serve to determine its exact name. But if it is a broken green-yellow or yellow-green the four disks, yellow, green, white and black will be required, but a larger number is never necessary.

EXACT COLOR NOMENCLATURE.

On all occasions seek to impress on the minds of the pupils the value of true names. There are some true names which are not very exact names. Eor example we may say that a certain color is a dark broken red-orange, or we may state exactly that it is red 10 parts; orange 15 parts; white 5 parts; and black 70 parts. Either of these names is correct and the less exact one for common use is far better than some fancy name of the dry goods dealer, as for example mahogany color.

For another illustration, a piece of silk sold as "ecru" when tested proves to be yellow 18, orange 14, white 21, and black 47, or in simple, truthful terms a light broken orange-yellow, or a light gray orange-yellow. This last name is true and as good next year as this, but the name adopted by the manufacturer or dealer means nothing this season and changes next season.

Another series of profitable tests may be conducted with much interest to the pupils in the form of puzzles. Let one pupil hold a sheet of card board in front of the color wheel while you make a combination of disks on the spindle and get them well "speeded up." Then have the card removed and while the disks are in rotation ask the class to guess what colors of disks are being used. Of course when the rotation ceases the disks become a *chart of the color* and all can see whether any one has guessed correctly or not.

One who has not had experience with pupils in using color disks can hardly imagine the interest with which they join in such color exercises, nor the wonderfully rapid progess they make in seeing and naming colors correctly.

ACCIDENTAL COLORS.

Thus far in our simple course of study we have been learning to see and name colors. The color perceptions have been trained and sharpened so that many qualities of color may be discovered, analyzed and accurately compared with each other. In our progress we have now come to a point or stage where a peculiar physical quality of our eyes called the accidental color or the after image may be profitably considered because of the wide influence which it exerts in all of our color experiences.

See pp. 17 and 18 Part I. of this book.

A first card for a class lesson regarding this phenomenon may be very readily prepared as follows:

Cut a circle from a square of standard red paper 4 x 4 inches, and mount it on a white card, say 6 x 12 inches as in Fig. 5. and make a prominent black dot at the center of the circle, and another dot at a similarly located point on the other half or blank part of the card.

Fig. 5.

To perform the experiment look intently at the dot in the center of the red circle for a half minute and then fix your vision on the other black dot for perhaps the same length of time and there will appear a circle of very light blue green, which is a tint of a color complementary to the spectrum red.

If similar cards are prepared in the other five standard colors the after image belonging to

each may be seen and thus an indication secured of the color complementary to each of the standards. The origin of this term "complementary" is not always understood by those who use it. White light is the sum of all colors, and if we remove from white light one color, as red for example, the remaining color effect is the complement of the red in producing the white light, and hence is called the complementary color of red.

If instead of a white card on which to project the after image we use some other color we shall then have the after image combined with this other color on which it is projected.

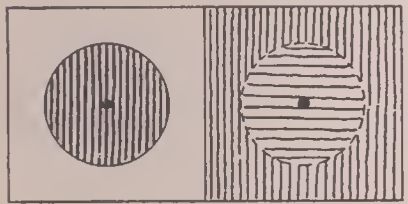


Fig. 6.

For example, as in Fig. 6, if we have a full red disk on a white card and on the other half of the card a larger square of a light tint of red, we shall have a blue-green after image projected on a tint of red, and these being complementary colors, the result will be a gray circle in a pink square. The color of this circle may vary from a pink gray through neutral gray to a blue-green gray, according to the nature or peculiar condition of the eye at different times; as the after image is stronger with some persons than with others, and not at all times alike with the same person.

If instead of a light red color the square is a tint of blue-green, the result will be a more brilliant blue-green circle in a lighter blue-green square. The reason for selecting a light tint on which to project the accidental color is that the accidental color effect is relatively very weak as compared with the effect of the full color under consideration, and hence in order to determine what color the combination of the two would produce each should be approximately of the same strength, and therefore we must use a tint rather than a full color for the background on the card.

In all these experiments a little practice will secure very pleasing effects even if at first the trial is not a success. The distance from the eyes at which the card will give best effects will naturally be somewhat different for different persons. With a four inch circle a distance of eight to twelve feet is satisfactory.

Another line of similar experiments may be arranged to show the mixed contrasts of Chevreul. On the left hand end of the card Fig. 7 there is a circle of full color, complementary to its background square. For example let the circle be full blue-green with its background square a full red, and on the other end of the card a square of blue-green tint. Now look intently at the center of the blue-green circle, and it's induced after effect will be a light red and that of the red square a tint of blue-green. Consequently when the eyes are fixed on the light blue-green square on the other end of the card the red effect excited by the blue-green circle will supplement the light blue-green of the card rendering it gray and the remainder of the square will be intensified by the blue-green after image of the red square.

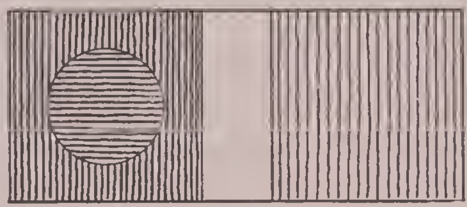


Fig. 7.

These experiments may be varied by using different colors complementary to each other, and in them may be found the key to a very large part of the good and bad color effects in nature, and possibly to the whole subject of color harmonies.

A careful trial of the foregoing series of experiments will afford a very clear idea of all the various optical effects, produced by the accidental colors or after images, and especially those classed as "negative after images." The value, to others than artists, of an acquaintance with the phenomena of simultaneous contrasts may be illustrated by a supposable case in real life. A lady wishes to purchase some material in dress goods or draperies, and has in mind a line of reds; the salesman, if he has a practical knowledge of his business, notices, after showing a number of different pieces of goods ranging through reds, crimsons and pinks, that his customer is becoming quite critical and not altogether inclined to be suited. He therefore remarks that he has some quite beautiful goods in the peacock-blue or blue-green hues and persists in showing them to his customer in spite of her protests that she does not want anything of that kind. In the meantime, however, the salesman has succeeded in keeping his blue-green goods before his customer's eyes

long enough to serve his purpose, for when she now looks at her original selections, they seem to have wonderfully pure colors, and she does not realize how it has all come about, because in her day the time of the children was not wasted in playing with colored papers when they should have been learning their spelling lessons or multiplication table.

CONTRAST OF COLOR.

The phenomenon of contrast of color is seen when two differently colored surfaces are brought together side by side as in Fig. 8. This represents a card having on it four sections of color from yellow to green, namely yellow, green-yellow, yellow-green and green. If this card is looked at intently for a few seconds with the eyes fixed on about the center of the band of colors the two central sections will seem to be graded in color from edge to edge, the green-yellow looking more green next the yellow and the yellow-green more yellow next the green. When this effect has been once experienced it increases and is more and more pronounced as the eyes become more affected, until it is impossible to believe that each of the four differently colored surfaces is of one uniform color from edge to edge. This effect may be very materially reduced and some times entirely obviated by outlining the figures or designs with white, black or gold as is often done in decorations in flat color.

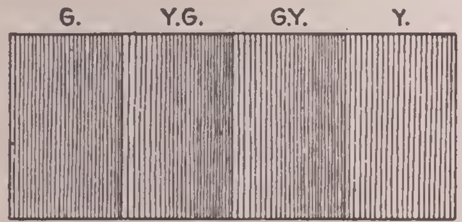


Fig. 8.

CONTRAST OF TONE.

A similar contrasted effect is seen where several grays of graded tones are placed side by side in contact with each other and arranged in order from the lightest to darkest. This may be beautifully shown on the color wheel or top by drawing a disk in black and white as shown in Fig. 9. In rotation this disk presents a series of neutral gray rings growing darker from the center to circumference. The color of each ring is a uniform gray from edge to edge, as we


Fig. 9.

know because the notches are formed by radial lines, but the effect in rotation is far different, as each ring appears graded from edge to edge from a darker to a lighter tone of gray.

Another series of illusions is seen if narrow strips of neutral gray paper are laid on a sheet of some full color, blue for example, as the gray no longer appears to be neutral gray, but a yellow gray. On red it has a greenish blue color, each colored paper producing its complementary effect on the gray. For some reason a gray is much more susceptible to this effect than white, and it also seems to be true that a gray is best adapted to give the complementary effect when its tone is nearly like the tone of the complementary of the given color.

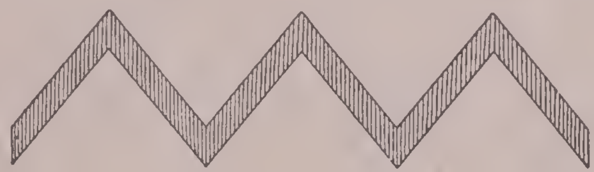


Fig. 10.

A zigzag strip as in Fig. 10. produces a pleasing effect, perhaps better than a straight strip.

This illusion is very beautifully shown on the color wheel as follows using three sizes of disks.

For example first place a largest red disk on the spindle, then combine the white and black disks of the next smaller size, and put them on to the spindle in front of the red disk and last put the next smaller size red disk in front of all. By rotation there will then appear a neutral gray ring on a red ground.

If the white and black disks are properly adjusted so as to give a g ay having a tone about like the blue-green complementary of red it will not seem possible that the ring is a neutral gray but rather a blue green gray.

Although these illusions are very interesting, they are not introduced solely because of the special interest in each, but because it seems to be quite evident that the various phenomena of Chevreul's simultaneous contrasts are very directly responsible for our sensations of color harmonies. This special point is not presented for argument, but as a suggestion to be kept in mind as we proceed to consider the harmonies of colors and the discords of color which are as effective for pleasure or annoyance to a person of trained color perception as are

musical harmonies or discords to the ear of the accomplished musician.

COMPLEMENTARY COLORS.

We may now return to the rotating disks on wheel or top for experiments regarding a somewhat definite study of complementary colors. As already stated, the accidental color or after image of any colored surface is practically its complementary color. It is not usually sufficiently intense nor permanent enough to furnish very definite results in color investigation or analysis, but it is sufficient to give us the key to our problems. If after taking red from white light the remaining effect or after image is as we have seen a color between blue and green, i. e., a compound of green and blue, we know that red, green and blue may be combined in such proportions as to produce the effect of white light. Therefore if we can determine this proportion we may solve the problem, and with the rotating disks this can be achieved better than by any other known means. In all practical color investigation we must base our experiments on material or pigmentary colors which are at best very impure as compared with the spectrum colors of sunlight, and therefore we cannot secure the pure white of sunlight when we combine the three colors either by mixing pigments or with the disks, but the disk combinations give very much better results than pigments and with disks in the standard red, green and blue, we may secure a positively neutral gray which is white in shadow or under a low degree of illumination.

Fig, 11.

Therefore if red, green and blue disks of the larger size are joined on the color top and on them are placed the small white and black disks in combination we have the means for solving this problem of complementary material colors more satisfactorily than in any other way.

This is shown in Fig. 11. Here the red, green and blue disks are combined in such proportions as to produce a neutral gray exactly like the gray made by the small white and black disks at the center. The proportions of the

Fig. 12.

color disks here shown are red 42, green 36, blue 22, and of the small disks, white 15, black 85. With the color top the disks are so small that it is not possible to secure such accuracy as with the larger disks of the color wheel, but results with the top may be secured sufficiently accurate to demonstrate the principle in a most interesting manner. Having obtained with this arrangement of disks the match in grays, if red is taken from the combination leaving green 36 parts and blue 22 parts, and these two quantities are increased in their relative proportion to fill an entire circle, we then shall have approximately green 62 parts and blue 38 parts, as in Fig. 12, and by rotation a blue-green which is complementary to red. This will be found a very interesting experi-

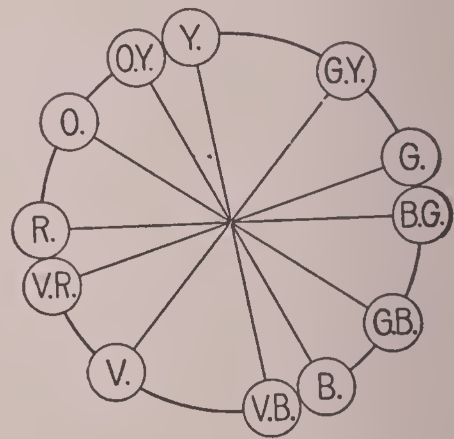


Fig. 13.

ment and may be repeated to determine the complementary color of each of the other standard colors, Orange, Yellow, Green, Blue and Violet. The accompanying diagram, Fig. 13, indicates approximately the complementary colors, although the yellow and blue are proba-

bly as nearly complementary to each other as can be determined in ordinary experiments. Thus we may demonstrate practically the fallacy of the old idea that the complementary of red is green, of yellow, violet, and of blue, orange.

COLOR HARMONIES.

The chief use of color is to give pleasure rather than profit, therefore the harmonies of color constitute the principal aim in the study of color effects.

It is the true determination of these qualities of color combinations for which color instruction is designed to ultimately prepare its students.

The aim of this system of color investigation is not only to analyze colors and thus be able to compare them with each other, and to compare the various opinions of individuals one with another, but ultimately to thus determine by general consent which color combinations are beautiful, which are fairly good, and which are ugly. These questions can be settled only by a majority vote, and the reason why practically nothing has thus far been decided is that there has been no language in which to discuss color combinations nor to record the deciding vote when taken. And thus there is no evidence that the present generation is more cultured in color combinations than were our ancestors of many years ago, in fact we have no means for learning definitely what colors were originally used in the works of the old masters because the pigments have faded and no record remains.

Classification is a valuable feature in the study of any subject, and a logical classification of the harmonies of color is most earnestly to be desired. While this may not be accomplished very perfectly for a long time, a very good beginning has been made in the selection of five general classes: Contrasted, Dominant, Complementary, Analogous, and Perfected.

The Contrasted harmonies are those in which color is contrasted with non-color, or more accurately in which an active color, i. e., a color from the spectrum circuit or any of its fairly pure tones, is contrasted with a passive color, white, black, gray, silver or gold. The simplest and one of the most pleasing of this class is a spectrum color in any of its tones

with white. In these combinations one result is common to all, the white is more intense and the color more brilliant, because the complementary effect, which has been noticed in the grays combined with color, is seen in a very limited degree in the white, and as far as it operates tends to intensify the color. We have already, under simultaneous contrast, observed the phenomena of contrasts, but little of this effect has yet been fully comprehended, and it will be possible to completely classify these only when a large number of accurate experiments have been made and recorded in a logical and definite nomenclature which shall be generally accepted.

While contrasted harmonies or combinations are more prominent and common, and seemingly the simplest, this class no doubt is more important and more general in its effects than any other, because in fact closely allied with if not identically involved in all the others.

Dominant harmonies are made by combining tones from the same color scale, and hence they are the simplest to make when the colored papers are employed. For example, a red tint No. 1, and a red shade No. 1, or again a green-blue tint, green-blue and a green-blue shade.

Complementary harmonies are those in which are combined opposite or complementary colors in the spectrum circuit. Tints of one color with shades of its complementary produce a more pleasing harmony than do complementaries which are similar in tone.

Analogous harmonies are produced by the combination of tones from scales of neighboring colors in the spectrum circuit. For example, a simple combination would be yellow tint No. 1, green-yellow, and yellow-green shade No. 2.

Perfected harmonies are those in which the general effect of one analogous harmony is complementary to that of another analogous harmony or in which the key tones of the analogous harmonies are complementary to each other.

COLOR STANDARDS, COLOR ANALYSIS AND COLOR DEFINITIONS.

All who have given intelligent thought to elementary color instruction have been met with the one difficulty that there have been no Standards on which to base investigations and

no nomenclature in which to record results of experiments. It must be evident to any one who studies this subject carefully that there can be no advance in its investigation until the fundamental truths regarding it have been discovered and some language generally accepted in which to express and discuss the results of experiments.

A popular writer on this subject has said: "To a chemist I can describe in language of the most precise and positive kind exactly the product I am for the moment talking about –and give the symbols–but this is impossible without a nomenclature so far as color is concerned; and it is only when this nomenclature has been formulated that the study of color work commences to be a science, for without this there can be no measurement of color sensations, or if it were possible to measure these we have no language in which to explain it that could be universally understood."

It is because of the general lack of knowlege regarding color that the vocabulary of color terms is so meager and so loosely employed. There is no other familiar subject where the descriptive words are so indefinite, or where even educated people find so much difficulty in expressing their ideas correctly. The dictionaries themselves furnish but little help, as it is their province to give accepted definitions rather than to coin new ones.

Hence there seems to be no hope for a better color nomenclature except in a popular education, through which there may be cultivated a definite use of words to interpret the various phases and facts of color which at present are more easily recognized than expressed, except by means of material samples.

It is not only in actual color names that our language is at fault but in the various qualities and modifications of color. For example, the word shade is commonly used to express any quality of a color properly covered by the three words hue, tint and shade.

Because of the differences in the opinions of physicists and colorists regarding the subject of color, a full list of concise and accurate color terms with their definitions in clearly understood words can hardly be looked for at present or in the immediate future, and yet as there must be a beginning, the following are offered as fundamental terms and definitions.

Standard Colors. The best pigmentary or material imitation of each of the six spectrum colors, red, orange, yellow, green, blue and violet, and white and black.

Spectrum Standards. The six colors in the solar spectrum definitely located by their wave lengths as follows in ten millionths of a millimeter: Red, 6571; Orange, 6085; Yellow, 5793; Green, 5164; Blue, 4695; Violet, 4210.

Pigmentary Colors. All colors used and produced in the arts and sciences such as paints or dyes and material surfaces and substances to which they are applied. This is in distinction from natural colors as in flowers and the Solar Spectrum.

Pure Colors. Pigmentary colors approaching as nearly as possible to corresponding spectrum colors.

Hue. That quality of color which changes from one location to another along the line of the spectrum circuit. The difference between a pure red and a pure orange is one of hue only. An orange hue of red is a standard red mixed with a smaller quantity of orange.

Tint. Any pure or full color mixed with white or reduced by strong sunlight.

Shade. A full color in shadow or obscured light. In disk combinations, a standard color and black produce, by rotation, a shade of the color.

Scale. A scale of colors is a series of colors consisting of a pure or full color at the center and graduated by a succession of steps to a light tint on one side and a deep shade on the other.

Tone. Each step in a color scale is a tone of that color.

Warm Colors. Red, orange and yellow, and colors in which they predominate.

Cool Colors. Ordinarily those colors which are not warm, especially blue and its modifications by green on one side and violet on the other.

Neutral Gray. White in shade or shadow. Pure black and white mixed by disk rotation.

Warm Gray. A neutral gray with the admixture of a small quantity of red, orange or yellow.

Cool Gray. A neutral gray with a small quantity of blue or blue-green.

Broken Colors. Gray colors. A most interesting and beautiful line of colors. A

tint of a color in a shade or shadow, or a shade in sunlight gives the effect of a broken color.

COMPLEMENTARY COLORS. As white light is the sum of all colors, if we take from white a given color the remaining color is the complement of the given color, or its complementary color, in forming white.

SPECTRUM CIRCUIT. If a pigmentary imitation of the Solar Spectrum be made with the addition of violet-red at the red end and red-violet at the violet end and the two ends joined, a spectrum circuit is the result.

PRIMARY COLORS. A term eroneously applied to red, yellow and blue by Sir David Brewster, who claimed that there were three distinct classes of colors, Primary, Secondary and Tertiary from which all other colors in nature and art could be made. See "Number of Standards" page 11, part I.

SECONDARY COLORS. According to the eroneous Brewster theory, orange, green and purple or violet were produced by the combination of red, yellow and blue in pairs and were called secondary colors.

TERTIARY COLORS. An indefinite series of broken colors in the Brewster System, made by combining the secondary colors, orange, green and purple in pairs to form russet, citrine and olive. See 'Broken Colors,' page 28.

WATER COLORS.

All color instruction leads up to the use of pigments, and when pupils have been thoroughly taught the systematic matching and naming of colors by means of the colored papers and the rotating disks, the teacher may profitably take them a step higher in their work by the introduction of water colors, which furnish the simplest form of pigments.

In the employment of this new material there is nothing new to be learned except its manipulation, as the principles are the same and the names of the standards and all the colors produced by their combinations are familiar. To make the transition simple it is necessary that the colors of the pigments be as nearly as possible like the standard spectrum colors found in the papers.

For this purpose water colors are now prepared in various forms, dry cakes, semi-moist in pans and moist in tubes, which as far as is possible with the chemical limitations, are made to match the six spectrum standards

already known by the pupils, with the addition of two or three grays.

Tints are produced by using thin washes made by diluting the pigment with water, and for the shades the grays are mixed with the standards.

No such accurate study of color effects and color terms can be secured by the use of pigments as are possible with the papers and rotating disks, but with the pigments in the six colors and grays as prepared to accompany this system of color instruction, very rapid and valuable progress can be made by young children in the transition from the papers to pigments.

They have for example already learned that the colors between red and orange in the spectrum circuit are made by combining the red and orange disks on the color top It is just so with the paints, and the same is true throughout the spectrum circuit, but instead of making two intermediate spectrum colors between red and orange as are found in the papers the pupils can now make an indefinite number, similar to the results with the disks and by the same combinations of colors.

COLOR-BLINDNESS.

The subject of color-blindness is of great importance and should receive careful attention from the teacher, but in the past very much has been charged to color-blindness which has been the result of color ignorance. With the best instruction in color from the kindergarten to the high school much of the so-called color-blindness will disappear.

In 1879 Dr. B. Joy Jeffries was engaged to test the pupils in the public schools of Boston for color-blindness, and in a pamphlet afterwards published containing his report to the school board he says: "In my report to the Boston school board on the examination of twenty-eight thousand children for color-blindness I said 'I envy the boys and girls who show on every school blackboard what can be done by thorough and systematic instruction of our sense form' and I said 'The cultivation of the other sense our eye possesses, that of color, is at present almost wholly neglected, as was once the sense of hearing and the voice.' The defect in this sense, viz., color-blindness, was of course as unknown as unrecognized." . . . .

Dr. Jeffries also says: "The teaching color and color names has been somewhat introduced into our primary schools where of course it must be commenced. There is, however, and this perhaps very naturally, no system whatever pursued as is with the education of the voice, the ear, and the sense of form in drawing."

According to the theories of Dr. Hugo Magnus, who has given much care to investigations regarding color-blindness this defect exists as red, green and violet blindness.

The red and green practically include each other, while violet blindness includes yellow blindness, but is extremely rare. The term "color-blindness" means that colors approaching the one to which the person is blind, appear more or less gray. A person who is red-green color-blind sees both of these colors as gray, while yellow and blue are seen in their true colors or approximately so.

Certain color tests should be so arranged as to detect either a defect in the brain by which it is difficult for the pupil to remember the names of the several colors, or in the eye, by reason of which he cannot see a difference between dissimilar colors. A person totally color-blind would see in the solar spectrum a band of grays only in various tones.

Because of the disagreement among prominent scientists regarding color-blindness teachers in the elementary grades cannot reasonably be expected to fully understand the various phases of the subject, but no color-blind child can be subject to the modern system of color instruction, even for a short time, without suggesting a radical defect to any interested teacher who understands the simplest elements of the subject. There can be no better tests than matching and arranging the spectrum colors by means of the paper tablets. If a teacher discovers that a child is unable to give the name of a color, this fact does not necessarily indicate a lack of color vision, but if after a reasonable trial, the various tests should seem to indicate a defect in this faculty, memoranda should be made from time to time for future reference, and if the result should seem to show a radical lack of normal color perception, the parents should be informed of the fact, and a competent expert consulted.

CUTTING AND PASTING DESIGNS IN COLORED PAPERS.

The work of cutting and pasting colored papers affords the earliest and perhaps the most profitable exercise in color combinations because it is comparatively cleanly. It is educationally valuable in the line of manual training in neatly cutting to lines as well as in marking the shapes by the use of cardboard tablets of various geometrical forms. The æsthetic training is found in the combination of various forms as well as the several colors. The occupations of drawing, cutting and pasting colored designs in papers to illustrate the various harmonies furnish most valuable desk work, covering a considerable range of useful occupations and mental training.

The order in which the colors can most profitably be taken up may to some extent be determincd by a careful consideration of the several harmonies as classified under the title "color harmonies," page 39. A contrasted harmony may be produced with colored papers by mounting on a white ground designs cut from any one color of paper. In this work form is the chief feature, as the contrasted effects which are found in all color combinations are reduced to a minimum when a single color is mounted on a white surface. When a gray surface is used the effect termed, by Chevreul, simultaneous contrast—See accidental colors, p. 32—is most pronounced, and should not be unnecessarily encountered by the youngest children, before they are old enough to understand to some extent an explanation of the phenomena involved; hence a white surface is most favorable for early work.

In a small book entitled Practical Color Work for primary and ungraded schools, by Miss Helena P. Chace, the author says:

"The application of color to form, in the lowest grade, if confined to the arrangement of borders, is very simple; and is quite suitable for desk work, or busy work. The tracing and cutting of figures in this grade require much oversight and individual instruction, hence the work in this direction is necessarily slow. In the next two grades it may be done more rapidly, and with greater satisfaction. Tracing around tablets is an

important antecedent of colored paper work, and may be done upon manilla paper. No units shonld be cut until some degree of skill in tracing has been acquired. Pencils used for tracing should have long, sharp points, and the side of the lead should touch the tablet. In passing around corners push the pencil a little beyond the tablet, thus avoiding a blunt or rounding effect. If the pencil is dull the line traced will be too far from the edge of the tablet, or if it is held in the ordinary position for drawing the point is liable to slip under the tablet. The practice in tracing should be followed by practice in cutting the units traced. For beginners a single figure of medium size is better than two or three smaller ones. In cutting circles the best effect is gained by teaching the pupil to cut close to the line outside. If a cut is made inside the line the circle is ruined, but if too far outside it is possible to improve the unit by a little trimming afterward. In cutting units with straight edges it is better to train the children to cut through the line itself, otherwise figures traced from the same tablet may vary in size and shape, as very slight deviations become quite noticeable when the unit is mounted. When a reasonable degree of skill in tracing and cutting has been developed then work with colored papers may begin.

The ordinary mucilage bottle is unsuitable for the use of young children because the handle of the brush is liable to become sticky, which is almost sure to result in an unsightly spot upon the work. Glass mucilage cups with screw caps, into which but very little mucilage has been poured, are very satisfactory. Small camel's hair brushes will produce much better results than the ordinary mucilage brushes, but they must be cleansed and dried as soon as couvenient after each lesson.

If you use *thick* mucilage do not blame your pupils for lack of neatness as the best work can be done when the smallest amount of mucilage is used. A thick paper requires a heavier quality and more in quantity than a thin one. Too much mucilage will make a thin paper stretch. Before mounting, it is well to lay the unit face downward upon a flat surface, *free from dust*, and apply the

mucilage aronnd the edge, but not touching the extreme edge; this allows for the spreading which is sure to take place if too much of the adhesive material is used. Then, lifting the figure carefully, place it in position without letting the edges touch until you are sure that its location is right. Press with the ball of the thumb firmly and rapidly from the center toward the edge, being careful not to pound or rub the paper. This insures smoothness. If not pressed with sufficient promptness the paper may both stretch and blister. If not gummed around the edges the work is liable to curl, and may become torn in handling. Pupils' hands must be free from dirt and perspiration and must be wiped upon a clean cloth after each pressure. If their hands perspire freely let them press with a cloth instead of the hand; but much care will be necessary, or a second application of the cloth may leave a spot.

In mounting borders, if a gray background is used that should be gummed into position first. Both margins should be gummed along the center of their entire length, and pressed in their proper places. This will assist the pupil in spacing. The units should then be arranged and removed one at a time, gummed and returned to place. In mounting rosettes the same principle applies but the central piece cannot, of course, be added until the rest of the design is complete."

A few simple borders and rosettes are here shown as suggestions of what can be done in cutting and pasting. Ready-cut papers in several of the forms are found in the Kindergarten material which may be used for mounting, by children who are not competent to mark and cut their forms.

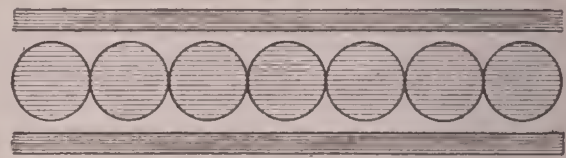


Fig. 14.

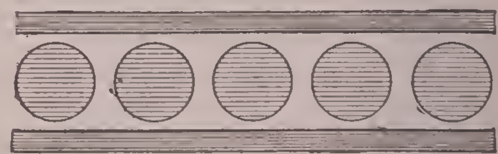


Fig. 15.

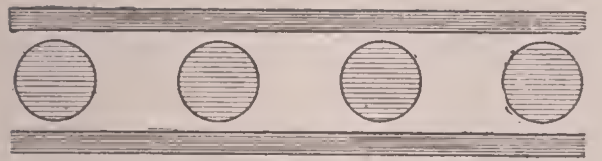


Fig. 16.

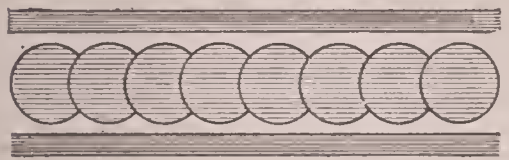
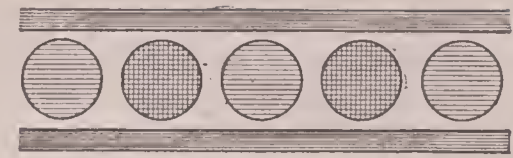


Fig. 17.

Fig. 18.

Fig. 19.



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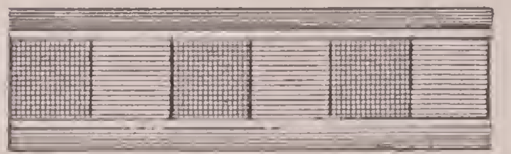


Fig. 21.

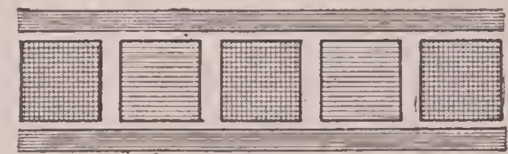


Fig. 22.

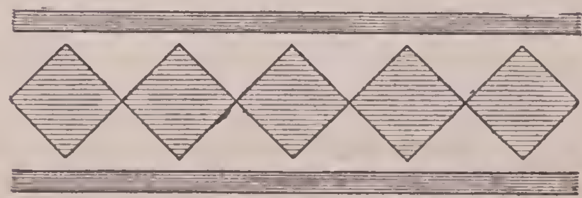
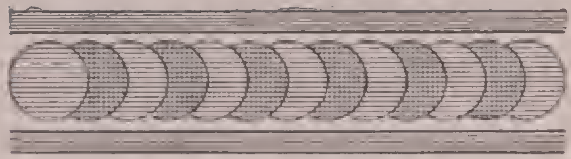


Fig. 23.



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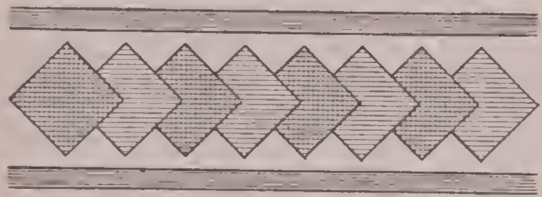


Fig. 25.

Fig. 26.

Fig. 27.

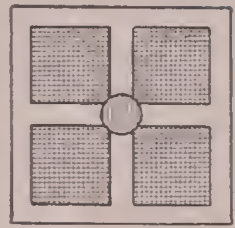


Fig. 28.

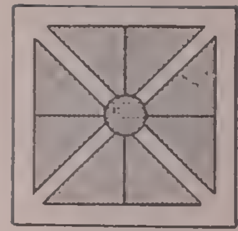


Fig. 29.

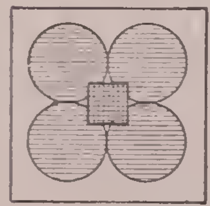


Fig. 30.

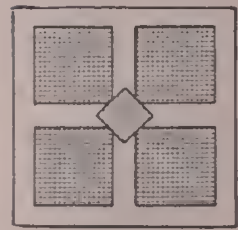


Fig. 31.

The work of cutting and pasting indicated in its simplest forms in these few suggestions which embrace the most elementary geometric forms only, may be profitably extended to a large variety of free cutting with folding. Directions in detail for this class of work can be found in "Papers and Scissors in the School Room," published by Milton Bradley Co.

MODERN CRITICISMS OF THE BREWSTER THEORY OF COLOR.

In the preceding pages brief mention has been made of the Brewster theory of color in which red, yellow and blue are designated as "primary colors;" orange, green and purple, made by mixing the primary pigments in pairs, are called "secondaries;" and citrine, russet and olive, formed by combining the secondary pigments in pairs, are classed as "tertiaries."

Probably few teachers who have intelligently adopted the theories on which these terms are founded will be willing to accept radical criticism of them without very definite corroborating facts supported by recognized authorities. Therefore a brief presentation of this color theory and the objections which may be truthfully urged against it seems necessary to a clear understanding of the subject and of the position and claims of the writer as expressed very briefly in these pages.

The theory of color based on the three classes designated as primary, secondary and tertiary colors, has not been discussed at length in the body of this manual because the writer believes it should not be mentioned to pupils unless reference to it seems necessary to correct erroneous impressions received by them outside the school.

It is hoped that with truthful instruction in our primary schools regarding color perception and color analysis these old and false theories will soon have been relegated to the past along with many other things in elementary education that have been stumbling blocks, because either wholly bad or so largely based on false premises as to be not only useless but actual hindrances to progress.

The Brewster theory of color has very largely dominated color instruction in the past because so generally accepted by artists, although for generations rejected as valueless by physicists. It is now known to be based on false beliefs to such an extent that it is erroneous in every peculiar feature claimed for it.

Even among our most intelligent lovers of color this old error must for a long time be met and combatted not only in its boldest and most evidently pernicious forms, but also in its more insidious and plausible phases by which

the same false ideas are somewhat concealed under new garbs.

Doubtless it will seem that one who claims no superior scientific or artistic knowledge must be incompetent to make such broad statements unsupported by recognized authority, and therefore the following extracts from opinions of those held high in public esteem are offered for careful consideration in addition to the expression of the writer's personal convictions.

Prof. A. H. Church of the Royal Academy of Arts, London, says in a valuable book entitled "Colour:"

"In an old and widely prevalent theory of colour it was assumed that there were three primary colours, red, yellow and blue, and that by mixing these in various proportions all other hues could be produced. Sir David Brewster not only lent the sanction of his great scientific authority to these assumptions but developed them into an elaborate theory which has met, until recent years, with very general acceptance. Yet Brewster's view of the existence of these overlapping coloured tracts in the spectrum is one that is incompatible with the simple character and definite refrangibility of every ray in the spectrum, with the entirely subjective character of the sensation of light, and with the simplest experimental tests of its truth which can be applied."

Regarding the tertiary colors of this theory, Prof. Church says: "The tertiary colours are supposed to be formed by the union of the three primaries in proportions different to those required to form white. But in reality tertiary hues are impossible. The tertiaries described by Chevreul, Hay, Field, Redgram and a host of other writers on color in its relations to art and industry, are nothing more than the dulled tones or broken tones of their so-called primary and secondary colours."

The practical truth of this statement regarding tertiaries is proved in no other way so well as with the rotating disks.

Dr. Ogden Rood of Columbia University says in his Text-book of Color: "This theory of the existence of three fundamental kinds of light, red, yellow and blue, is found in all except the most recent text-books on physics,

and is almost universally believed by artists, nevertheless it will not be difficult to show that it is quite without foundation."

Although this was published more than fifteen years ago the statement regarding artists is true to-day with the exception of some who have given attention specially to color instruction in elementary schools and thus have had their attention called to the old errors.

Speaking of certain experiments regarding the effect of colored light on colored surfaces Prof. Rood says: "They are certainly useful in teaching us, when studying from nature, fearlessly to follow even the most evanescent indications of the eye, utterly regardless of the fact that they disobey laws which have been learned from the palette."

Nature surely is a better teacher than the palette or Sir David Brewster and his followers.

In a small pamphlet entitled "Hints for Teachers of Physiology," by Dr. Bowditch, of Harvard University, the author suggests a simple hand-made "color teetotum," the forerunner of the present popular "Color Top," and in this connection makes the following explanation of the two phases of the red, yellow and blue theory of primary colors:

"If, for instance, a blue and a yellow disk are placed upon the teetotum in such a way that each occupies about half the surface, the mixing of these colors by the rapid movement of the teetotum will produce the effect of white light, since blue and yellow are complementary colors. * * * *

"The experiment with blue and yellow paper will doubtless suggest to the mind of some pupil familiar with painting, the question why blue and yellow thus mixed produce white instead of green, as when mixed on the painter's palette. To explain this point the pupils may be requested to look through a piece of blue glass and a piece of yellow glass placed so as to overlap each other. It will be seen that the light coming through both glasses has a green color.

"In accordance with the Young-Helmholtz theory of color, these phenomena are explained as follows: The retina contains elements specially adapted to be stimulated by rays of light of the three primary colors, red,

green and violet. The sensation of white light is produced by the simultaneous stimulation of all three sets of elements, while that of yellow light is due to the stimulation of the red and green perceiving elements, and that of blue light to the stimulation of the green and violet perceiving elements. Hence, when blue light and yellow light fall together upon the retina, as in the experiment with the teetotum, all three sets of retinal elements are stimulated and the sensation of white light results.

"On the other hand, blue and yellow glass owe their respective colors to the fact that the former absorbs the red rays and transmits the violet and green rays to the eye, thus producing the sensation of blue; while the latter absorbs the violet rays and transmits the green and red rays, thus producing the sensation of yellow. The green rays therefore are the only rays that can get through both sorts of glass. Hence the sensation of green light is produced when white light is transmitted through both blue and yellow glass before it falls upon the retina. The mixing of colors upon the retina by the rapid revolution of the teetotum may be described as a process of *addition;* while in the experiment with colored glasses a successive *subtraction* of the different colored constituents of white light occurs. *The mixing of colored pigments resembles the latter process, since their color depends upon their power to absorb rays of certain colors, and reflect back others to the eye.*"

Although it may seem unreasonable on first thought it is nevertheless true that a definite knowledge as to which colors are complementary to each other is as necessary to good art as the knowledge of the effects on each other of two adjacent colors. On this point Prof. Barnard, in his elaborate book "The Theory and Practice of Landscape Painting in Water Colors," writes as follows: "Thus the colors of material objects vary according to the light by which they are viewed. A sand-bank for instance, observed partly in a bright light and partly in shadow, will not appear altogether of its true color, yellow. The part under shadow will not reflect a sufficient portion of yellow rays, and the bright yellow of the other part will have a tendency to produce on the eye the effect of the accidental color."

The problem in this case is, What is the resultant effect of the complementary of yellow when projected on the gray yellow of the shadow? The complementary of yellow is a blue, very slightly violet, and therefore the effect must be a result which can be imitated by rotating combined disks of yellow, blue and violet, with the addition of a black disk to supply the shadow, cast on the yellow, and this result will necessarily be either a yellow-gray, a neutral-gray or a violet-blue gray, but by no possibility a green such as results by the mixture of yellow and blue pigments.

Thus it is absolutely necessary for best results that an art student shall be able to correctly predict what color will result from certain conditions which may be suggested to him or which he may encounter in nature, in order that he may reproduce the color effect correctly, so greatly is vision influenced by mind. For example, if the interior of a room is tinted blue and the light in the room comes through yellow glass in the windows the color of the walls will be a gray, either a neutral gray, a yellow gray or a blue gray, according to the relative strength of color in glass and ceiling, but the Brewster theory applied to this condition would dictate the use of green for the interior. Again, if we spread over a blue ground a veil of yellow lace and view it from a distance the effect is a gray, but an artist educated according to the Brewster theory if making such a composition without having all the conditions in his model, might assume that the yellow veil and blue vase should form a green, in fact tradition says this has actually occurred on an occasion when the yellow lace was not at hand but was introduced for its effect in the general composition.

Water Color paints corresponding as nearly as possible to the Bradley Standards have been put on the market and thus render possible and simple many interesting and valuable details of color investigation in this line, which heretofore have not been practicable in elementary experimentation.

As a test of the truth and practical value of the Brewster theory, the standard red, yellow and blue pigments of this line of water colors may be selected and combined in pairs to form the secondary colors, orange, green

and violet or purple of the Brewster school, and the best results in each combination can be chosen for comparison with the corresponding standard colors. Such experiments have been made with the following results:

First, the red and yellow pigments combined in different proportions produce various colors from yellow-red to red-yellow. From these several mixtures of pigments applied to paper one of the colors was selected as the nearest approximation to the orange of the original set of six pigmentary spectrum standards. Similar experiments were made with the green and with the violet. These selected samples of secondary colors, orange, green and purple when analyzed with Maxwell disks of the Bradley standard colors give the following equations, showing results so definite that they can be fully corroborated with the small disks of the color top if a color wheel is not available.

The secondary orange thus made by mixing the red and yellow pigments when compared with combined disks of standard orange, white and black, equals in a total of 100 parts, standard orange 46, white 3, black 51. A similar analysis of the green made from yellow and blue pigments is standard green 24, white 3, black 73. The violet made from red and blue pigments is standard violet 21, white 1, black 78. Thus it is seen that the orange is shown to be less than one-half pure color and each of the other two less than one-quarter pure.

The definite selection of six spectrum colors as superior to three, five or seven, the location of these colors in the solar spectrum by their wave lengths and the closest practicable material imitation of them, constitute the peculiar features of the Bradley Color Standards. The use of the Maxwell rotating disks made in these six standard colors and white and black furnishes a definite nomenclature of colors, simple, accurate and convenient, the Bradley colored papers afford a pure and economical material for primary color teaching, the corresponding water color pigments provide a means for carrying out the same principles in higher art, and the whole system brings us into as close acquaintance with the pure colors of nature as the limitations of material colors will allow.

PART III.

HOW WE SEE COLORS.

HOW TO SEE AND TALK ABOUT COLOR.

WHITE LIGHT CONTAINS ALL THE COLORS.

I suppose you know, children, that all the colors are wrapped up in the sunlight. Yes, the white light which is all around us contains some of every color you ever saw. How do you suppose I can prove this to you? Why, if we could only manage to get one little beam of sunlight all by itself in the dark, and pick it to pieces, we could find out what it is made of, just as you pull a flower to pieces and see all its different parts.

I am going to show you how we can spread out the different parts of a small piece of sunshine and look at them one by one and see all the beautiful colors. This will be one of the prettiest sights you ever looked at.

OUR EYES MUST HAVE LIGHT.

But first let me tell you a little more about the light and how it is that we can see the things about us, and then you will understand the experiment better. If some of you were shut up with me in a room without a window or open door, or a single crack to let a ray of light in, and we had no lamp or other light it would be pitch dark. We could not see one another nor anything in the room, and so we know that we must have light in order to see the shape or color of any object.

If a lighted lamp were brought into this dark room, we should at once see the bright flame because the lamp would send out rays of light to our eyes. Then we could see the white walls of the room, because the rays of light would strike against them and rebound to our eyes, just as a ball, when thrown against the wall, will rebound to your hands. The other objects in the room could also be seen, for they would send back to our eyes either all or a part of the rays of light which fell upon them.

Now let us go out of the dark room with

its dingy lamp light into the bright sunshine, and here we find the same thing true. The light of the sun falls on the houses, the grass, the trees, the sky, and is reflected back to our eyes. When we stop to think of all this it seems quite wonderful, because the same light which shines on the brick block falls also on the trees, and yet the bricks are red and the leaves of the trees are green. Another house may be white and the flowers in your garden are blue and pink and violet, and still we see all these objects because the same light from the sun falls on them and is reflected to our eyes. Now you begin to see that what I said at the start is true, about all the colors being wrapped up in some way in the sunshine.

We get so used to looking at these colored objects that we do not realize how wonderful it all is, and do not even ask how it is that we can see such beauty all around us. No one knew much about it a few years ago, but now it can be explained by simple experiments.

I will tell you the secret in a single sentence. When the sun shines on a house painted white all the light is thrown back to our eyes, but when the same sunlight falls on the green leaf of a tree, part of the light is lost to our senses and only the green rays are reflected to our eyes.

THE WORK OF THE PRISM.

Now let us go into the dark room again and I will show you how to pick a bit of sunlight to pieces. All we want is a big sheet of white cardboard and a thick piece of glass with three edges, called a triangular glass prism. When everything is ready we let a little beam of the bright sunlight into the room through an opening in the window shutter. Then we put the prism right in this streak of light in such a way that the rays are thrown upon the cardboard, and what has happened? Why, instead of a white spot on the cardboard the glass prism has separated the beam of sunshine into its different parts, and we see a beautiful band of colors, which you will notice is like a piece of a very bright rainbow. The drops of water in the air sometimes act on the sunshine much as the prism does, and that makes the wonderful rainbow.

THE SIX STANDARD COLORS.

This band or patch of color is called the

sun spectrum or the solar spectrum, and if we have succeeded in getting a good one you can pick out at least six colors, namely, red, orange, yellow, green, blue and violet. You know these colors because you have seen them in familiar objects, such as a red apple, an orange, a lemon or a buttercup, green leaves and grass, the blue sky and the modest violet.

In teaching color these six have been taken as standards and colored papers have been made as nearly as possible like them. We have seen that when all the rays of light are reflected to our eyes from any object, as the white walls of a room, we call that object white, and so when no rays are reflected the object is called black, because where there is no light we say there is only darkness or blackness. If we make a very white paper and a very black one to add to our six papers imitating the principal colors of the spectrum, we shall have a set of standards with which we can compare all other colors.

OTHER SPECTRUM COLORS.

But you must know that our six standards are only a small part of the great number of colors. If you look at the spectrum you will see many other colors besides the standards, and the same is true in the natural objects about you. A great many things may be called green, just as the children in one family are named Smith. But there may be Mary Smith, George Smith, Sarah Smith, and so on, just as there are in the Green family of colors, a yellow-green, a blue-green, a light and a dark green, and so on.

COLORED PAPERS.

The papers referred to above are prepared for use by being cut into small pieces, two inches long by one inch wide, called colored paper tablets, a little study of which will make you so familiar with the various colors that whenever you see a color you will recognize it because it is like one of your tablets, which has its own definite name.

The tablets are prepared in four assortments, each assortment put up in a numbered envelope, 1, 2, 3 or 4.

No. 1 envelope contains one piece each of red, orange, yellow, green, blue, violet, white, black and two grays. You have seen that the colors in the spectrum are arranged in the order just named from red to violet, and if

you remember just how they come you will be able to select and arrange the papers in the same order, and also to name each tablet.

The white and black pieces will be easily recognized, but the other two tablets in this envelope called light gray and dark gray, you will not think attractive, perhaps. They will, however, be found to be very useful. If a piece of white paper is held in a strong light at a window and a shadow thrown upon it, that part of the paper on which the shadow falls is a gray. If you can get the light just right the shadow may look like one of your gray tablets when the tablet is held in the full light but near the shadow so that the two can be compared. You will learn later that there are many kinds of gray, and this gray which is like the shadow on a white paper is called neutral gray because it has no bright color in it, although, for convenience, we call white, black and gray, colors.

TINTS AND SHADES.

When you have learned all these ten colors so that you can name them and can arrange the six bright colors in their spectrum order you may have another set of the tablets, found in envelope No. 2. The same six bright colors which you now recognize will be found there, and many others. These six colors are called standard colors. If you take one of them, for example the red tablet, and hold one end in the sunlight you will see that the part in the sunlight looks much lighter than the other part of the tablet. This effect is called a tint of the red, and again if you hold this same tablet in a good window light and cast a shadow on it from the window the part in the shadow will be a shade of the red. These two effects of tint and shade are imitated in two of the pieces of paper in this new set and you may be able to select them as looking more like the red tablet than any of the other colors in the envelope.

A COLOR SCALE.

If you can now choose each of the six standard colors and its tint and shade you may be able to lay all the eighteen colors in the form of a chart, see Fig. 1, beginning at the top with the full red paper and laying on the right hand side of it the shade and at the left the tint. Below this row the orange row may be laid and so on down to the violet.

Each one of these rows of colors is called a scale of color. The three red pieces make the red scale of three tones. You cannot remember all these terms at once, but some time they will seem very simple to you.

RT1	R	RS1
OT1	O	OS1
YT1	Y	YS1
GT1	G	GS1
BT1	B	BS1
VT1	V	VS1

Fig. 1.

Thus far you have learned to recognize and select six scales of three tones each, and know what "Standard color" is, and that the standard when made lighter is a tint, and when darker is a shade.

In addition to these six Standards of color there are other colors in the spectrum which do not seem to be very clear in such a spectrum as can be secured in a room which is not very dark. But with a very perfect glass prism and a very dark room, many other colors can be seen between the red and the orange, and between the orange and yellow, etc. For the study of color two colors have been made in the papers between the red and the orange and between each other two standard colors nearest to each other in the spectrum. In the third envelope of color tablets the papers show between the red and orange a red with some orange in it and an orange with some red in it. One we call an orange-red and the other a reddish orange. So there are yellow-orange and orange-yellow.

COLORS NOT IN THE SPECTRUM.

And then there are some colors which are not found in the spectrum. These colors are such as you could make if you should take some pure red paint and some pure violet paint and mix a little violet into some red which would make a violet-red, and a little red into some violet to produce a red-violet. In this way we have eighteen colors which you may find among the little paper tablets. When you can lay all these in their proper order from the red to the violet you

will have two left. Those you have laid will represent the spectrum, and the two pieces left over represent colors not in the spectrum, but made by mixing red and violet paints and are called a violet-red and a red-violet. If you now lay all your papers in a circle instead of a straight row with each piece laid the

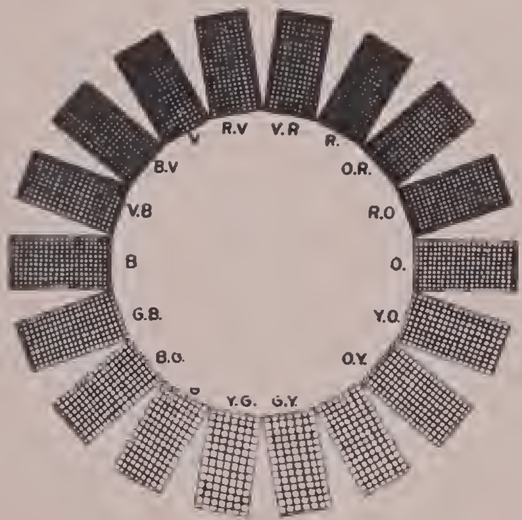


Fig. 2.

longest way, running from the center of the circle to circumference like the spokes of a wheel, thus bringing these two odd colors together as shown in the accompanying figure, near the top of the circle, you will have produced a spectrum circuit, (see Fig. 2), having completed the circuit by adding the colors between the red and violet which are not found in the spectrum but which are common in nature and the arts and commonly called purple.

MIXING COLORS.

Now the wisest man could not describe in words every different color so that they would be understood without samples to look at, but I am going to show you how we can take the colored papers. made to imitate the six standard colors and white and black, mix them so as to show all other colors and then name all new colors so that we can tell our friends what each one is, and even write the true name of each color, just as we make words and name objects with the letters of the alphabet.

There are no colors in flowers or in our silks so pure as those in the spectrum, but colored papers are made in such variety and in such pure colors that a great deal can be learned from them about color; so that when one of you should wish to become an artist, a chemist in a silk mill, a decorator of china, a worker

in gold or enamel ornament, or a milliner, or even when you might merely want to select the furnishings for a home, you would be able to make beautiful combinations in color.

These colored papers have been made especially to train our eyes to see all colors and to know what to call them. Every color may have a true name by which we can call it whenever we meet it. First we can say to what family it belongs and then, if we have given careful attention to the colored papers, we can give it its particular name in the family.

Such papers may not only teach us colors, but they may be folded and cut and pasted in beautiful forms, and afford much pleasure and instruction in this way also.

A FAMILIAR EXPERIMENT.

Probably you have all seen a stick with fire at the end of it whirled around so rapidly as to form a perfect ring of fire. This is another wonderful thing but few people stop to ask what causes it. I wonder if I can explain it so that you can remember it.

The reason why we see anything is because the eye is fitted with a lens and a back screen like the lens and plate in a photographic camera, but the impression made on this screen is not fixed and lasting like that received by the photographic plate. Still it remains a very little while, and when the stick is whirled rapidly the impression made at one instant remains long enough for the stick to make an entire circle, and thus a full ring of light is seen.

THE MAXWELL DISKS.

On the same principle, Sir Isaac Newton, a learned man who lived two hundred years ago, discovered that he could make several colors come together into one by painting them on a wooden top and then spinning the top. This color top of Newton's was very much improved some years ago by an Englishman named Maxwell. He had been painting disks of cardboard in sectors or the shape of a piece of pie, making the pieces in different colors and then placing the disk on a rotating spindle to see what colors would result. This was interesting but when he wanted a different combination or different proportions of colors he was obliged to paint a new disk, which took much time. Finally the idea came to

him that by taking two or more disks of thin card or paper and cutting a straight slit from the edge to the center of each, they could be combined and show a portion of each, so that when he had tried one combination he could change so as to show more or less of the colors desired, and then at once spin the top again. So from this little invention these disks as shown in Figs. 3 and 4 have ever since

Fig. 3.

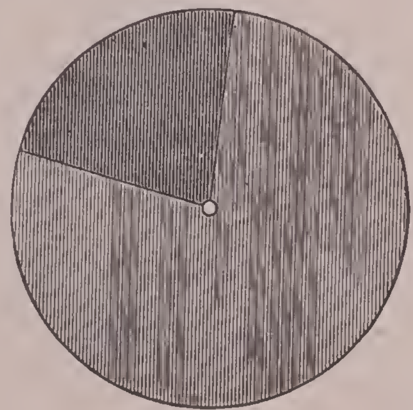


Fig. 4.

been called Maxwell's color disks.

Fig. 3 shows how two of them, having been cut from circumference to center, are joined together, and Fig. 4 represents the full face view after the union is effected, the centers coming together and a large part of one disk and a small part of the other showing.

COLOR WHEEL AND TOP.

Fig. 5 is the color wheel and you can see how the disks are fastened on. This is for the teachers to use before the whole class, but there is also prepared for you a small wheel called the color top and shown in Fig. 6. With this little instrument, after brief instructions you can follow the teacher's work and even perform experiments of your own. In examining the top you will see that the peg fits a circular piece of thick, hard cardboard, and there is a little wooden collar which fits quite closely to the stem of the peg as it is pushed down against the cardboard. This top is sold in an envelope with two sets of disks, one smaller

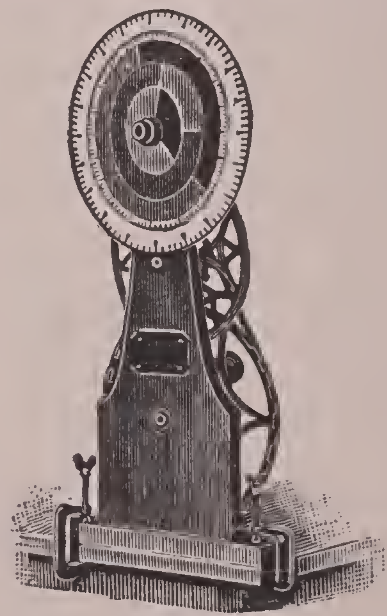


Fig. 5.

than the other, each set comprising one each of the six standard colors and white and black. With this simple outfit a large number of instructive experiments can be performed by any ingenious boy or girl who has had instruction. Some of them will be explained, as they illustrate many of the facts of color seeing, and by such study the eyes will be trained to see many things which, otherwise, would never be noticed.

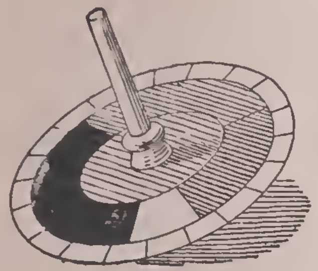


Fig. 6.

Suppose one of the two disks shown above is green and the other yellow, then when they are whirled rapidly what do you suppose you will see? Not green nor yellow but a new color, the larger surface of yellow being modified by combining with it the smaller quantity of green, forming a green-yellow.

HOW TO NAME THE COLORS.

I promised to tell you how to name any color so that it can be written down and sent to a distant friend, and I can now make it plain to you. The standard green and yellow being fixed and accepted, the same combination used in Fig. 4 will always produce the same color, and if we can record the exact amount of green and yellow it can be reproduced at any time, whenever one has a top or a wheel. This work can be done more exactly on the larger disks of the color wheel, but you can get very good results with the little top. There are marks on the outer circumference of the cardboard disks used on the wheel, by which it is divided into 100 equal parts, so that the exact proportions used for any given color can be determined at a glance, as in this case 22 green and 78 yellow.

Let me tell you how to do the same thing with the top. You will see marks around the edge of its cardboard disk. When you have made a pleasing combination by spinning the top, count how many spaces are taken by each color. Every space stands for five parts out of a hundred, and so, for example, if you have on your top, yellow 4 spaces, green 8, white 2 and black 6, that means that you have yellow 20 parts, green 40 parts, white 10 and black 30, making 100 parts in all. You can write down

the number of parts you have used of each color, and whoever has a color top can fix the disks on in the same way and make the same color, no matter what it is. So we can not only make a color but we can name any color which we have seen.

I have already told you how the strong sunlight on a standard color will make a tint of that color, while a shade is produced by taking the standard out of the strong light and putting it into a shadow. So with the color top we make an orange tint by adding to the orange disk a little of the white one, and an orange shade by adding some of the black to the orange. A lighter tint may be made by putting in more white and a darker shade by the addition of more black. In the same manner we can make tints and shades of all the standards.

THE HUES.

In this study we must learn to be exact in our use of terms. Between each pair of standards there are in the spectrum a variety of colors and these we call hues, therefore these intermediate hues are made by combining on our color top two of the standards which come next each other in the red, orange, yellow, green, blue and violet spectrum. Beginning with the red and orange disks, by using a large amount of the red and a small amount of the orange we have an orange-red, and by taking a good deal of orange and a little of the red we make a red-orange. So take the yellow and green disks and make a green-yellow and a yellow-green.

Let us see what we have done in our experiments thus far. We have combined the white disk with each standard and produced different tints, and by using the black disk in place of the white we have made the shades. We have also put together the standards in pairs to make the intermediate hues.

ADDITIONAL TINTS AND SHADES.

Now we can proceed to make tints and shades of the hues, also, by combining three disks instead of two on our color top. For example, an orange and a yellow disk make an orange-yellow or a yellow-orange, while by using an orange, a yellow and a white disk together we can produce tints of the various hues, and by replacing the white with a black disk we make shades of the hues. In this

way an almost endless variety of tints and shades can be made.

If the white and black disks are combined the result will be a shade of white or a neutral gray, quite an important feature in color study.

PURE AND BROKEN SPECTRUM SCALES.

Let me say another word about the pretty effect that may be made in colored papers by what is called scaling colors. The scale represented by Fig. 7 is the standard orange scale. Beginning at the left we have orange

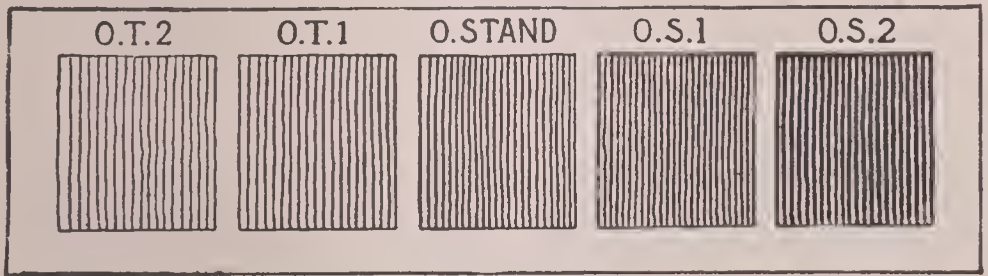
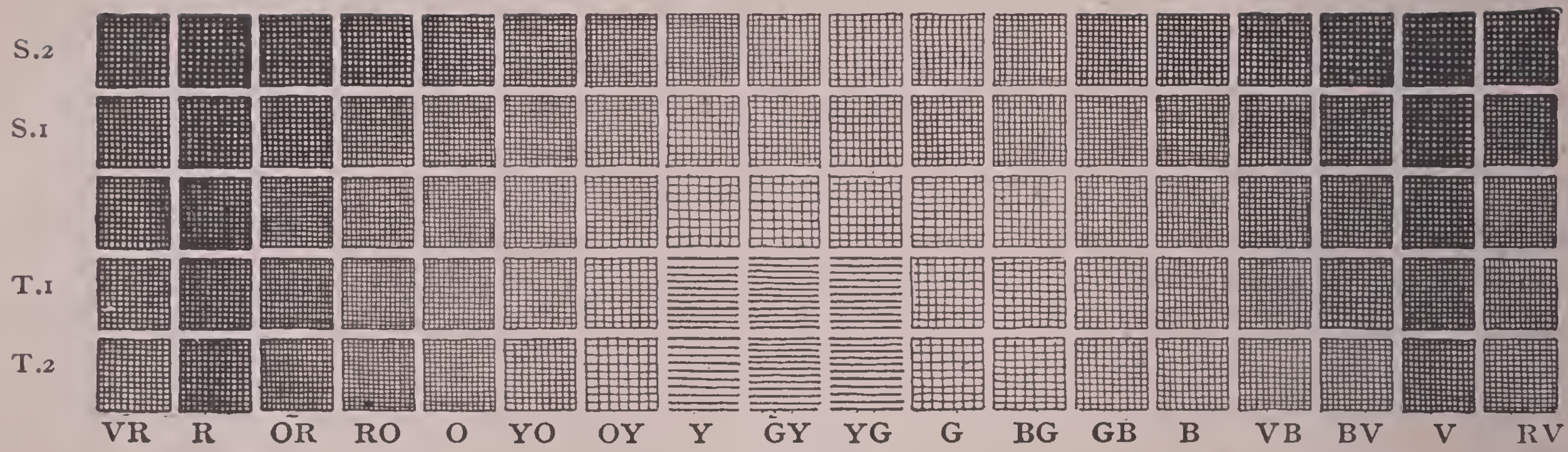


Fig. 7.

tint 2, the lightest color in the scale, then orange tint 1, orange standard, orange shade 1, and orange shade 2, the darkest color in the scale. We make six of these scales of the six standards and then if we take two hues between each pair of standards and scale them we shall have in all eighteen scales of five tones each. Thus we have ninety colors in our chart all named, as you will see by Fig. 8, called the chart of pure spectrum scales.

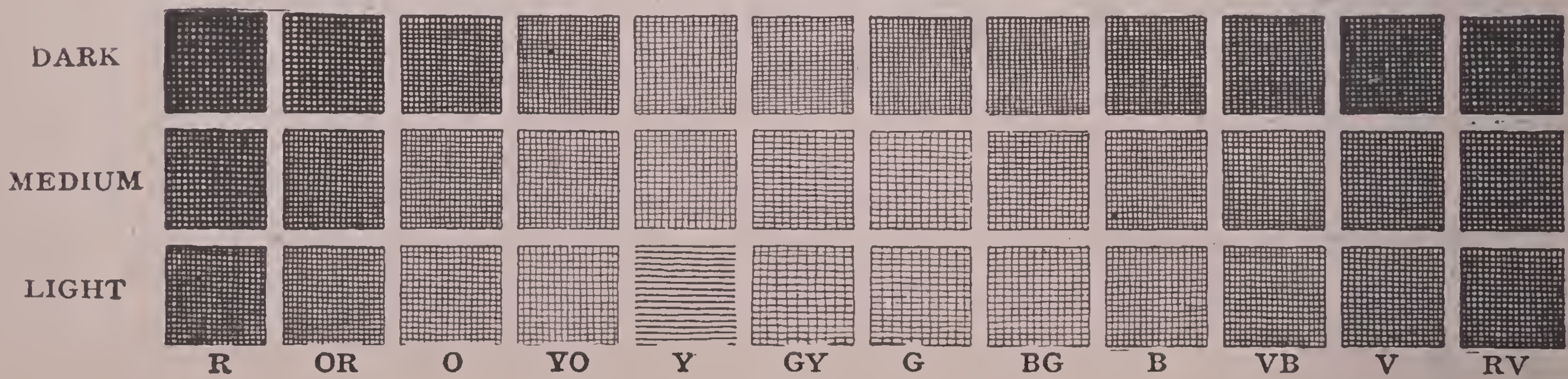
Now if we take the red disk and use it with both the white and black disks we shall have a combination of red and gray, which will produce a gray-red or a broken red. By mixing different proportions of the red, white and black we can easily make three tones of broken red. Then if we treat in a similar manner each of the six standards and one intermediate hue between each two, we shall have twelve scales of three tones each, or thirty-six colors in all, as shown in Fig. 9, the chart of broken spectrum scales.

The chief difference between these two charts is that the first consists of the pure, bright colors of the spectrum, while the other is made up of these pure colors dulled by mixing with them neutral grays. Another difference is in the number of hues and tones. There might be ninety of these in the chart of broken colors if we chose to make them,



S.2
S.1
T.1
T.2
VR R OR RO O YO OY Y GY YG G BG GB B VB BV V RV

Fig. 8.



DARK
MEDIUM
LIGHT
R OR O YO Y GY G BG B VB V RV

Fig. 9.

and there could be any number of colors in either chart.

BROKEN COLORS.

From all that has been said you will doubtless recognize the truth of the statement when I tell you that nearly all the colors seen in nature are broken colors. The vapor and other impurities in the air even on a clear day all tend to draw a veil between our eyes and the objects looked at. Therefore the study of broken colors becomes a most important and fascinating part of this whole subject, and it has an added interest from the fact that nearly all the colors found in ladies' dress goods, carpets, paper hangings, etc., come under the head of broken colors.

But in the beautiful flowers from our gardens we find the nearest approach to pure spectrum colors. By closely observing these and other objects in nature and art you will get both pleasure and profit. By the word "nature," I mean to include such objects as flowers and trees, the sky and the grass, the mountains and all birds and other animals, while the word "art" covers things that are manufactured or fashioned by the hand of man.

There are many curious things in connection with this subject that will both surprise and please you. For example you can sometimes see color where there is none. You found this to be true in regard to light, when I spoke about the ring of fire made by a rapidly whirling stick. The fire is actually only in one place, that is, at the end of the stick, and yet you see a perfect ring of it, because, as I told you, our eyes have the power of retaining the vision for a short time.

ACCIDENTAL COLOR.

There is something called accidental color, which furnishes a striking example of seeing color where there is none, and I will show you an easy way of producing it. Take a white card, say 2½ by 5½ inches in size, and paste upon one end of it a 1½ inch circle of standard red paper. Make a black dot at the center of the circle and another one at the other end of the card at the same distance from the end. Now look for half a minute at the dot in the circle of red, and then look at the other black dot, and soon you will see a circle of very light blue-green, which is a

tint of the color complementary to the red. (See Fig. 10.)

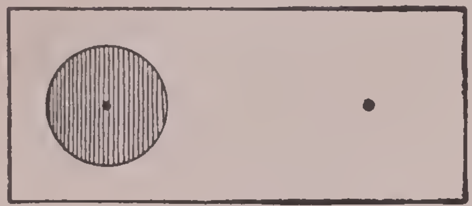


Fig. 10.

If cards are prepared with circles of the five other standard colors similar effects will be produced and a hint obtained as to the complementary of each standard.

COMPLEMENTARY COLORS.

But I have not told you what this long word, "complementary" means. As all colors are contained in the white light of the sun, if we take away from white a particular color, all the others combined make a new color which is complementary to the one taken away, that is it is the color which, added to that taken away, will make white. Just as in numbers you might take two away from five and call three, all that is left, the complement of two, because two and three when put together make five. So take the color red for example. If we can find out what color with red will make white, then that color is complementary to red.

The colored papers are the nearest imitations we can get to the pure spectrum colors, but still they are so far from pure that by no possible combination of the different colors can we produce pure white. But we can make a color like white when in a shadow which is a gray, and such a gray can be made by joining white and black disks on the top. The gray thus made is called a neutral gray because it has no tinge of any of the spectrum colors.

Fig. 11.

Therefore if we can discover which colors of disks to put with a red disk so as to secure a gray like a white and black gray as made

with the disks we shall have discovered the complementary of red. Because the pigmentary colors are impure as compared with pure sunlight colors, such as are seen in a spectrum, the result of combining two impure colors which are complementary to each other will be an impure white which is a neutral gray, such as is made by the combination of a white and a black disk.

Fig. 12.

Now it has been found that red, green and blue in certain proportions on the color wheel or top will produce gray the same as can be made by a combination of a white and a black disk. This is shown in Fig. 11.

Therefore a blue-green, made by combining green and blue in the same proportions as seen in Fig. 12, is the complementary of red. In the same way the complementary of each of the other standard colors may be found.

The complementary of orange is a color between the blue and green, that of green is a violet-red and that of violet is a color between yellow and green. As for yellow and blue they are very nearly complementary to each other.

CONTRASTS.

A pleasing effect in the contrast of colors is made by mounting several differently colored papers close together on a card. Fig. 13 represents a card with four colored pieces of paper on it, yellow, green-yellow, yellow-green and green. If you

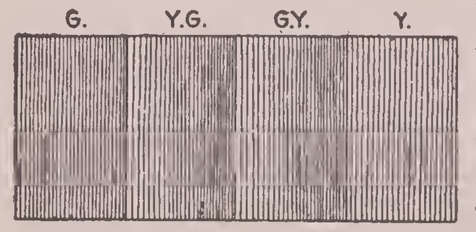


Fig. 13.

will look intently at about the center of this card a short time each color will appear to change from edge to edge until it will be hard

believe that each of the sections is of one uniform color.

Another beautiful effect, called contrast of tone, can be produced by making a black and white disk as shown in Fig. 14. When rotated this might be expected to present four neutral gray rings, each distinct in tone from its neighbor, and uniform in tone from edge to edge, but in reality each ring appears graded from one edge to the other.

Fig. 14.

Another interesting illusion is seen by laying strips of neutral gray paper on a sheet of a standard color. Strips made in a zigzag form like Fig. 15 show this effect better than straight ones. On blue the gray strips have a yellow tinge, on red they look greenish blue, etc., each bright color producing its complementary effect on the gray.

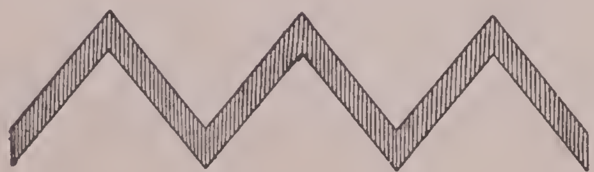


Fig. 15.

COLOR HARMONIES.

When your eyes have been trained by working with colored papers, there isn't one of you so color blind that you will not be able to tell the difference between a pleasing combination and one that is not pleasing. You can see at once that some colors lose a great deal of their beauty when put beside each other, while others become more beautiful. In the spectrum itself one color merges so gradually into another that we get no violent contrasts. This is a great part of its loveliness and it is a secret worth remembering when we come to try our hand at producing harmony in colors.

You know in music when two notes are not in harmony they make a discord. That is they make a sound that is unpleasant to our ears, and we call it a noise. When the two notes harmonize the effect is music instead of mere noise. It is just so in color, and the

more we educate our eyes the more delight we shall have in beautiful harmonies.

When two colors are separated by white, black or gray or by gold or silver the harmony is almost always improved. This is seen in the Union Jack of Great Britain, in which the red and blue are separated by narrow stripes of white, and in the United States flag a white stripe, instead of a red one, comes next below the blue field.

Harmonies are made with tints and shades of the same color, with tones from the scales of neighboring colors in the spectrum, and also by combining opposite or complementary colors. This whole subject of harmony forms an important part of color education, and before leaving it I shall be obliged to introduce to you a few hard words.

Any subject which we desire to study will be made more simple if we are able to classify it. So it is well for you to know that the subject of harmony has been divided into these five classes: Contrasted, Dominant, Complementary, Analogous and Perfected.

If you take what we may call a live or active color such as a standard red or any of its pure tones, and place it beside a dead or passive color, as white, black, gray, silver or gold, you will get a sharp but not unpleasant contrast; hence this is called a contrasted harmony. The combination with white is always pleasing, the result being to brighten up both the white and the color with which it is brought in contact.

Dominant harmonies are made by comparing tones from the same color scale, complementary harmonies by combining opposite or complementary colors in the spectrum circuit, analogous harmonies by bringing together tones from scales of neighboring colors in the spectrum, and perfected harmonies are those where the prevailing tones of the analogous harmonies are complementary to each other.

It is a great advantage in color study that we have such convenient material as colored papers. They are so cheap, so easy to work with and produce so many pleasing combinations, that we could make but slow progress without them.

PLEASING EXPERIMENTS.

It will be very interesting for you to bring from home pieces of cloth of various colors

or other substances and try to match the colors with the paper disks on the color top. Flowers and leaves will also afford you great pleasure. In these experiments you will find it convenient to lay a piece of glass over the leaf or cloth and spin the top on the glass, looking down upon it from above.

If all the children of this generation are not artists when they grow up, they ought surely to have the artistic sense well developed. Your fathers and mothers had no such opportunities as you enjoy of having the eye trained to see and value colors.

The general ignorance which pervails is shown by the small number of color terms in use and the loose and unintelligible way in which even these are employed. How often we see in a newspaper such an announcement as this: "There are seventy-five different shades in dress goods this summer." Knowing now the true meaning of the word "shade," you will see that the newspaper, in the above announcement is prophesying a gloomy season, if all kinds of color except the shades are wanting. The dictionaries themselves give but little help, reflecting the popular lack of accurate information. One of them says that "two shades of scarlet are different tints."

Although there is great difference of opinion over the exact meaning of color terms, even among those who have given the subject some thought, I will undertake to give you a few simple definitions.

Color. That quality of an object which we can perceive only with our eyes.

Standard Colors. The best possible material imitations of these six spectrum colors: red, orange, yellow, green, blue and violet.

Natural Colors. All colors found in the sunlight, and in flowers, foliage, minerals and all natural objects.

Pigmentary Colors. All colors used in the arts and sciences, as distinct from natural colors.

Hue. By this word we indicate a change of color along the spectrum circuit; an orange-red is an orange hue of red.

Tint. A pure color diluted with white or in a strong light.

Shade. A pure color in shadow or com-

bined with black by means of the rotating disks.

SCALE. A series of colors consisting of a full color with tints of the same on one side and shades on the other.

TONE. Any step in a color scale from the lightest tint to the darkest shade.

WARM COLORS. Red, orange and yellow and all colors in which they predominate.

COOL COLORS. Blue-green, blue and violet.

NEUTRAL GRAY. A mixture of white and black by means of the rotating disks, a white surface in a shadow.

WARM GRAY. A neutral gray mixed with a small quantity of a warm color.

COOL GRAY. A neutral gray mixed with a little green-blue, blue or violet-blue.

BROKEN COLORS. Colors mixed with gray.

COMPLEMENTARY COLORS. Two spectrum colors which, together, will make white light, or two material colors which, by rotation, will produce neutral gray.

SPECTRUM CIRCUIT. A spectrum circuit is made by adding violet-red to the red end of the spectrum and red-violet to the violet end and then uniting the two ends to form a circle.

WATER COLORS.

When you have become well acquainted with the use of the colored papers, so that you can match and name any color, you can then continue the work with the aid of water colors. These will give you much pleasure, for you will find that the names of the colors and their combinations and the principles which are to govern your work are all familiar, and that you will have to learn only how to handle the new material.

The water colors are prepared in three forms, dry in cakes, semi-moist in pans and moist in tubes, and you will see that they are made to imitate the six standard colors as closely as possible, and that two or three grays have been added to make the shades. The warm gray with the warm standards will imitate the shades of those colors, and so also with the cool gray. The tints are produced by thinning the colors down with water. You must not expect the same unvarying effects as in the use of the colored papers but you can get a great deal of valuable instruction with the water colors.

One real advantage to be gained by this

study is the ability to make harmonious combinations in color, an acquirement which you will find of much practical value all your lives. But besides this, a true appreciation of color will greatly add to your enjoyment of both natural and artistic beauties.

Everything you can see has some color, although the great majority of objects look very dull and uninviting if you view them without thought. But, remembering what I have told you about broken colors, a little study will enable you to find something interesting in things which at first you might think not worth looking at. Some of these broken colors are exceedingly rich and beautiful, but even when they are not so there will be great satisfaction in studying them, for thereby you will be learning to appreciate even more highly the beauty of the sky, the grass, the flower, the plumage of the bird and other brilliant objects.

The Bradley Standard Water Colors.

The elementary work of the Bradley Color Scheme comprises the use of colored papers and experiments with the prism and the rotary disks. To supplement this work and to complete the material for a logical system of color instruction, a line of water colors representing the Bradley Standards is now offered.

An illuminated metal box, black and gold, contains eight cakes of dry colors, red, orange, yellow, green, blue, violet and two grays, warm and cool.

Another box of similar design, in blue and gold, contains the same eight colors, semi-moist in pans; and in addition to these two forms the same six standards, with warm, neutral and cool grays, are made moist in tubes.

With rotating disks in the six standards and white and black all colors in nature and the arts can be produced, and so in pigments with the same simple collection of colors similar results can be secured, the grays being used in place of white and black.

For prices see below.

Price List of Color Outfit for Primary Schools.

	Price.	Postage.
Primary School Color Wheel, with Disks, ...	$3.00	
Extra Set of Disks for above, in Portfolio, . . .	.75	$ .06
Color Top, ...	.05	.01
Color Top, per Dozen, ...	.50	
Water Colors, dry, per box, ...	.25	
Water Colors, semi-moist, per box, ...	.35	
Water Colors, moist, per tube, ...	.10	
Prices for extra cakes and extra pans furnished on application.		
Color Primer, Teachers' Edition, ...	.10	
Color Primer, Pupils' Edition, . , . . .	.05	

No. 1 Prism, ...	.10	.01
No. 2 Prism, ...	.15	.03
No. 3 Prism, ...	.30	.04
Wax Crayons, Standard Colors, ...	.10	.02
Rainy Day Spectrum, ...	.10	.04
Large Spectrum on cloth, thirty inches long, . . .	.25	.04
Chart of Pure Spectrum Scales No. 1, X, ...	.50	.10
Chart of Pure Spectrum Scales No. 2, X, ...	1.00	.15
Chart of Broken Spectrum Scales, No. 1, ...	.50	.10
Chart of Broken Spectrum Scales, No. 2, ...	.75	.15
Chart of Complementary Colors, ...	.50	
Paper Tablets, Sets No. 1 and 2, ...	.02	
Paper Tablets, Set No. 3, ...	.03	
Paper Tablets, Set No. 4, ...	.04	
Sample Book of Colored Papers, ...	.05	.01
Package, 4 x 4 papers, 100 pieces, Assortment A or B, . .	.20	.04
Package, 5 x 5 papers, 100 pieces, " A or B, . .	.30	.05
Package, 6 x 6 papers, 100 pieces, ...	.30	.07
Package, 6 x 9 papers, 50 pieces, ...	.30	.05
One Sheet Coated Paper 20 x 24, any color in sample book, .	.04	
One Sheet Engine Colored Paper, 20 x 24, any color in sample book,	.03	

To insure safety by mail each order is enclosed in a pasteboard cylinder, which makes an additional charge of five cents to be added for any order however small.

Assortment A, named in the above list of prices, contains the six spectrum standards with one tint and one shade of each and grays.

Assortment B contains the intermediate hues with one tint and one shade of each. A list of the assortments in the other packages will be furnished on application.

MILTON BRADLEY CO., Springfield, Mass.

A NEW LINE OF SEWING CARDS.

To supplement our "Perforated," "Outline Perforated," "Outline Printed" and "Pricked Sewing Cards," we now offer a series of "Outline Pricked Sewing Cards" produced by a new process which enables us to make prices that otherwise would be impossible.

Card-board sewing is one of the most popular as well as useful Kindergarten occupations. Formerly "pricking" formed a separate occupation in the Kindergarten, preceding the sewing, but this has been so generally and vigorously criticised by physio-psychologists that there has come to be a very general demand for ready-punctured sewing cards, which make available the valuable occupation of sewing without the nervous effects of the pricking exercise on the children or the tedious labor of pricking by the teacher.

A valuable and popular advance in this class of material is found in the "Outline and Pricked" cards here described.

In this series there are four styles of cards; 5 1-2 x 7 1-2 inches, 4 x 5 1-2 inches, 3 1-2 x 3 1-2 inches and circular cards 3 1-2 inches in diameter. Each card bears a design indicated by a dotted outline in which at suitable points a clear large hole is pricked in the card. The dotted outline is not only shown on the face of the card but is quite clearly seen on the back, which is of advantage with the youngest pupils. For these four series of cards new designs with long stitches have been prepared, simple, artistic and effective when worked.

PRICES OF THE
OUTLINE PRICKED SEWING CARDS.

	Price	Postage.
5 1-2 x 7 1-2 inches in box of 100 cards	$1.00	$0.44
4 x 5 1-2 " " "	.55	.25
3 1-2 x 3 1-2 " " "	.35	.15
3 1-2 inch circles " "	.35	.15

MILTON BRADLEY CO., - - Springfield, Mass.

New York. Atlanta. Kansas City.


THE MILTON BRADLEY CO.
STANDARD.
WATER COLORS